REINFORCING A PUBLIC LAWN

by

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(Under the Direction of BRUCE K. FERGUSON)

ABSTRACT

This thesis investigates two potential solutions for the problems of sparse grass cover, soil compaction, tree mortality, and poor drainage within a heavily used quadrangle at the University of Georgia (UGA). Cu-Soil and Netlon's Advanced Turf were evaluated on the basis of being retrofitted in the study area in order for water, air, and essential elements to infiltrate into the soil. With either of these sustainable systems in place, people could use the public lawn year-round, while the quadrangle's main components of lawn, soil, and trees, would not be irreparably damaged. The final section enumerates the costs for retrofitting each solution.

INDEX WORDS: CU-Soil, Netlon Advanced Turf, sustainability, stormwater, landscape management

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DEDICATION

To my dear family: Mike, Andrea & Carl, Mom, Dad, Jesse & family, & my cats

Without your love, support, patience, and understanding, accomplishing this dream could not have been possible. Thank you for believing in me.
You are the joys of my life!

With all my love,
Olivia

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

On university campuses today, there is nothing more alluring to a student than a lush green lawn. These verdant green spaces, or quadrangles, surrounded by stately, historic buildings have precedents at Oxford and Cambridge dating back to the 13th century. The lawns present an inviting place for studying, socializing, and relaxing. Hard work by university maintenance crews keeps these areas in pristine condition. A closer look at these particular landscaped areas reveals that they represent more than an inspiring design element. In actuality, these green spaces are microcosms for larger landscape architectural problems (Johnson, 754). Communities everywhere are dealing with issues related to depleting natural resources, stormwater infiltration and attenuation, compacted and useless soil, urban tree survivability, and porous versus impervious pavements. Now it is time to find "green" solutions for these environmental problems that threaten sustainability. This thesis examines the problems of sparse grass cover, compacted soil, tree mortality, and poor drainage on a UGA quadrangle; however, this situation could impact any public lawn. It focuses on how to make existing components of this campus quad: the lawn, the trees, and the soil, an ecological structure that, along with stormwater, mimics nature and accommodates pedestrian activities. It studies two available technologies: (1) turfgrass grown on a high sand content rootzone with reinforcing mesh mixed in the rooting media; and, (2) turfgrass grown on structural soil. Appendix A enumerates the costs of retrofitting these technologies on the UGA quadrangle.

AN AILING QUADRANGLE

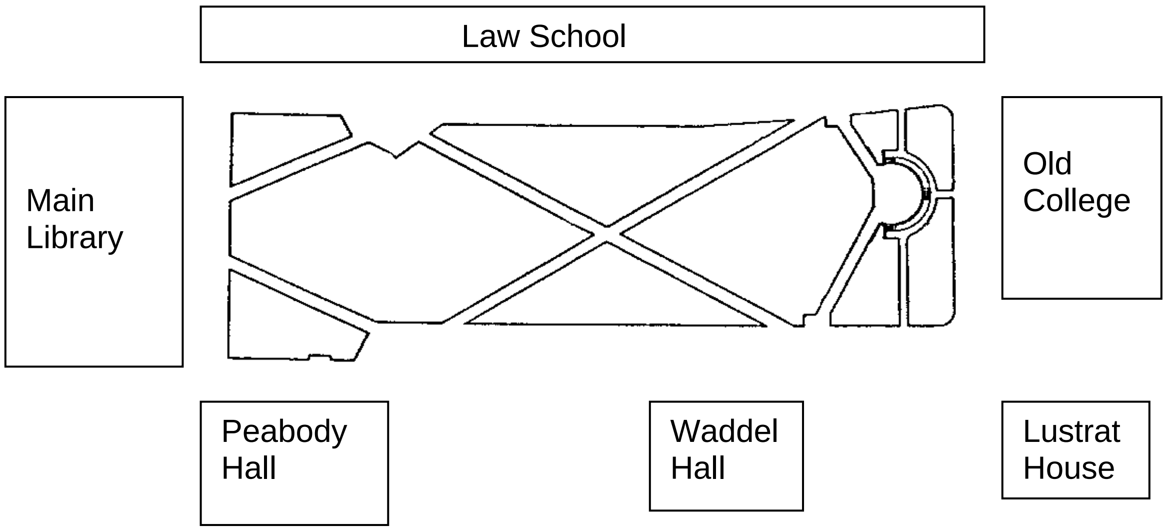


Figure 1.1 The Quadrangle **Drawing by OAM**

The quadrangle that is located between Old College and the Main Library at the University of Georgia in Athens is the study area of this thesis. The Old College, the University of Georgia’s first building, separates the two main quadrangles, which are the focal point of North Campus. The Law School, Peabody Hall, Waddell Hall, and Lustrat House are the other buildings that frame the study quad. Old College and Waddel Hall are centuries-old buildings which are part of the university’s origin and are listed on the National Register of Historic Places. Some of the oak trees in this space are centuries-old, too. An integral part of this quadrangle is the President’s Garden. It is located on the south side of Old College. In addition to the 150’ x 300’ centrally located, tall-fescue lawn, the quadrangle has twelve foot wide concrete sidewalks that are utilized by both service vehicles and pedestrians. Eight foot wide concrete pedestrian paths criss-cross the lawn. Students have worn additional paths into the grass in their routine circulation from one side to another. The quadrangle is irrigated by a series of rotors, which provide full coverage of the grass. In-ground catch basins collect stormwater and pipe it to a nearby creek.

THE PROBLEM

Since the study quad is one of the main areas on campus, UGA's landscape maintenance crew is quite vigilant about keeping it tidy and free of all debris. Following such maintenance any visitor walking along UGA's North Campus would find this area quite attractive. As a result, it is a popular place that hosts a number of outdoor events and lots of people, especially during home football games or May graduation ceremonies. A home football game, especially, brings on a multitude of tailgaters. (See picture on pages 38 and 39.) Sadly, the grass gets trampled and worse, the soil underneath is compacted and impervious to air and water. What results is tree and grass die-back, erosion, mud, and stormwater run-off.

Figure 1.2 The Thesis Area
Photo by OAM

In an attempt to repair the quad, the landscape maintenance crews run core aerators over the grounds which pull out 4" plugs of soil. This procedure is an attempt to get water and air to tree and grass roots. Next, heavy machinery vacuums the plugs, in effect, sealing most of the holes. Additionally, heavy machinery may spread sand, to level out areas, or grass seed, to patch existing grass. Then, two foot banding is put up to keep people off the grass. (See picture on page 38.) Every year these same, traditional landscape maintenance procedures are repeated.

PURPOSE

This thesis will explore whether there is a more successful, sustainable, and cost effective way to treat a landscape management dilemma on the University of Georgia campus. There are available technologies on the market that make it possible for people to congregate, relax, and have fun on lawns and under shade trees without deleterious effects. Also, these technological advances make landscape maintenance a simpler process. Two environmentally sensitive solutions are examined for extending the life of the public lawn and trees by allowing air, water, and essential elements to infiltrate to root systems below grade. Furthermore, the ramifications of successfully retrofitting one of the reinforcing systems on the UGA quad could spawn some important lessons in sustainable landscape construction and maintenance practices, urban tree survivability, and stormwater infiltration and conservation on campus.

METHOD OF STUDY

The method for this thesis was primarily intense research on the subjects related to turfgrass, soils, Cornell University's structural soil, and other varieties of structural soils, trees, porous pavements, stormwater drainage, and campus design. Also, some research was devoted to the history of the University of Georgia and on lawns in the United States. The study area was observed for an entire year, and many photographs were taken. Some information was gathered from key personnel at the University of Georgia, Cornell University, inventors of different varieties of structural soil, and arborists at Bartlett Tree Experts laboratory. Trips to Cornell University's Urban Horticulture Institute in Ithaca, New York, UGA's Turfgrass Research Institute in Griffin, Georgia, Bartlett Tree Experts Research Facility in Charlotte, North Carolina, and the University of South Carolina at Aiken, South Carolina, helped meld theories with evidence. Finally, completed landscape projects by Cornell University, Erth Products, the Carolina Stalite Company, Netlon Advanced Turf Systems, and Glenn Rehbein Companies provided good case studies for understanding reinforcing elements for turfgrass and soil.

DEFINITIONS

There are several terms used in this thesis which may be unclear to the reader. They are:

permeability: allowing water and air to infiltrate the turfgrass to soil strata underground.

porosity: refers to the void space in soil where tree roots, water, air, and nutrients can move through.

porous pavements: surfaces such as turf, pervious concrete, and porous asphalt that allow water to infiltrate, or pass through, to the soil below, while bearing traffic.

structural soil: a load bearing soil that consists of a homogeneous, or open graded, angular rock for strength underneath pavements, clay loam soil, and hydrogel as a tackifier.

sustainability: refers to the protection and conservation of natural resources (water, air, and trees) in order for them to be plentiful for future use.

tensile strength: capable of distributing a heavy load stress.

turfgrass, sod: both refer to a grass lawn; They are used interchangeably.

urban forest: trees that are planted along streets, in parks, plazas, islands, and neighborhoods in cities and urban communities.

CHAPTER 2- LAWN HISTORY

Lawns have been an integral part of American college campuses since their introduction to the first universities in New England over three hundred years ago. They are desirable spots for study breaks, relaxation, recreation, and social gatherings. Campus lawns offer respite from crowded classrooms and the claustrophobic indoors. They have evolved into coveted green spaces within institutions of higher education. Yet, their importance goes well beyond the ivy-covered walls. Now, in the wake of major environmental issues that plague the world, green spaces are paramount to sustainability.

The first lawns date back to the Middle Ages, when monasteries cultivated small, formal, geometric shapes of grass within their courtyards. This architectural style, in which buildings surrounded the grass on all four sides, termed a “quadrangle”, was introduced at Oxford and Cambridge during the early 1200s. The quadrangle, as the focal point in campus plans, set the precedent for each of the nine U. S. Colonial universities that were chartered between 1636 and 1780.

When Harvard, America’s first university, was built in the early seventeenth century, it was a single building adjacent to a grassy open meadow called a “common” or “green”. The open meadow functioned as public green space and as a training ground for the militia (Newton, 249).

In Thomas Jefferson’s plan for the University of Virginia (1817-26) the central tiered lawn was the centerpiece of the design. At UVA, Jefferson ushered in a new form of campus planning. The opening of the lawn at one end of the quadrangle composition, toward the mountains, had the effect of visually extending the campus out into the distant landscape (Teyssot, 77). It was the lawn that unified both site and structures (Dober, 117). Many have called UVA's lawn "the most beautiful outdoor room in America." (Beiswanger, 21). From this point forward in early American campus planning, many of the images made to represent the universities incorporated lawns as a unifying, harmonizing feature (Teyssot, 77).

Initially, the first few buildings at the University of Georgia (1785) were patterned after Yale University (Boney, 1). As the city of Athens, Georgia, enveloped the university grounds, the quadrangles on North Campus emerged as the heart of the campus. Today, according to a campus design survey taken by Professor David Spooner, from the School of Environmental Design at UGA, 82% of the students named the quadrangles as the their favorite spaces (*College Planning & Management,* June, 2006, 54-59). Additionally, Professor Spooner learned that 64% of the times that these students occupied these green spaces they were studying (Ibid). His conclusion suggests that the quadrangles, at least at the University of Georgia, offer an escape from a traditional classroom and are becoming the preferred places for learning (Ibid).

MORE GREEN SPACES NEEDED

In recent years, UGA has made consistent efforts to "green up" more of the campus. Two landscape developments underwent a metamorphosis from impervious pavements to green spaces. The Herty Field project involved removing a parking lot on North Campus and creating, in its place, a small grassed quadrangle with a fountain and seating around the perimeter. The grass has no trees on it and is used extensively by students, faculty, and staff, for a variety of events. Brooks Mall, which begins on South Campus and is being installed piecemeal northward to the center of campus, is a tree-lined lawn that replaced Brooks street.

Green spaces are valued on campuses across the country. Northeastern University in Massachusetts, removed a large portion of their hardscaping (areas covered in concrete or asphalt) in order to create grass quadrangles and planted areas (*Landscape Architecture,* May, 2001, 63-69). At the University of North Carolina at Chapel Hill, new, stricter policies were instituted to protect and preserve the declining one hundred year old trees in the four quadrangles at the center of campus. One of the new rules requires that groups of two hundred or more must pay to have temporary fencing put up and then removed around a tree's dripline (*University Gazette*, August 30, 2006).

Now, more than ever, campus lawns and green spaces filled with mature trees allow connections be made between humans and the outdoors. This connection is vital in order for communities to think more about sustainability and conservation of our natural resources.

CHAPTER 3: THE QUAD'S ENVIRONMENTAL COMPONENTS

Figure 3.1 Quad Components   Photo by OAM

In a "natural" ecosystem containing turfgrass, soil, trees, and stormwater, components sustain each other. The soil anchors the lawn and trees. The grass keeps the soil from eroding and it filters pollutants from stormwater. The trees intercept rainfall and shade the soil. Rain infiltrates to plant roots and recharges groundwater, which provides streams a steady base flow. Water and oxygen, which both the lawn and trees release into the air, are necessary to sustain life. People, the end users who inhabit this ecological structure, utilize the lawn and shade themselves under trees.

The sample UGA quadrangle could function as a self-perpetuating eco-system. Instead, the malfunction of one element is creating a domino effect on the system as a whole. The compacted soil is causing grass and tree die-back, which is not acceptable for environmental, aesthetic, or functional reasons. The situation basically creates a maintenance problem. As a result, fencing is put up to keep people off the lawn, which defeats the purpose of a public lawn. Additionally, compacted soil is causing stormwater runoff because it cannot infiltrate below grade, where it can provide water to plant roots and recharge groundwater. The runoff, in turn, deposits pollutants and sediment into local streams and rivers. So, the question is what can be done to restore and maintain porosity and permeability to the soil so that stormwater, air, and essential elements infiltrate to roots and, consequently, sustain the lawn and trees?

Before a satisfactory design solution can be suggested, a piecemeal examination of the quad's individual components-- turfgrass, soil, trees, and stormwater-- must come first. The assessment will provide information as to how each element functions singularly, and in relation to its coexisting elements. This information will contribute beneficial contextual information as well.

TURFGRASS

A beautiful, well-maintained lawn provides aesthetic, recreational, and environmental attributes to a public landscape, like a university campus. Aesthetically, its textural quality and rich color can accentuate a building's architecture. It is mentally soothing to look at and touch. For recreation, people like relaxing and playing on its soft, flexible surface.

Turfgrass benefits the environment in several ways:

- It absorbs carbon dioxide from the atmosphere and emits oxygen.
- It counteracts heat radiating from masonry and impervious materials (heat island effect) by heat dissipation
- It traps dust and dirt and builds them into the soil structure.

- It absorbs noise and glare.
- It filters pollutants from stormwater.
- It minimizes erosion and runoff.

(Sawhill, 243)

There are only a few genera of grasses that are suitable for use as lawns. They can be divided into two groups: warm-season and cool-season turfgrasses. For sustainability and manageable upkeep, choosing the right grass is crucial. The primary selection considerations depend on a lawn's intended use, its growth habits, the geographical region, the soil texture, and the amount of required maintenance. Otherwise, time, labor, and money are wasted. For example, it would be foolish to install a warm-season grass in New England. The grass would never survive the cold winter. Likewise, cool-season grasses, when planted in sandy soil in a warm climate, need plenty of shade and irrigation to keep them from wilting and dying.   The concept of, "right plant, right place," should come to mind when considering where to establish a lawn.

Temperature dictates turf adaptation more than any other factor (Brede, 103). Warm-season grasses are normally found in the southern one-third of the United States. They possess a more efficient form of photosynthesis under intense sunlight, heat, and drought stress (Brede, 38). They grow best in summer at temperatures above 75 degrees Fahrenheit (Decker, 257). Included in these species are: bermudagrass, centipedegrass, St. Augustinegrass, zoysiagrass, carpetgrass, and bahiagrass.

Cool-season grasses thrive in the northern portions of the country. They grow best in the spring and fall in temperatures below 75 degrees Fahrenheit (Decker, 254). Included in these species are: tall and fine-lawn fescues, bluegrasses, ryegrasses, and bentgrasses. These grasses stay green all year, permitting sports play during winter when warm-season grasses would be dormant brown (Brede, 48).

Knowing how a particular turfgrass grows and establishes itself in a space is important, as it affects a lawn's overall appearance and repairs to damaged spots. Most turfgrasses produce rhizomes (underground stems) or stolons (lateral stems that grow across the soil surface), or both, which are important in knitting the plants into a tight sod (Decker, 47). A fourth growth habit is the bunch-type grass, which forms small clumps and spreads actively by seeds (Sawhill, 705).

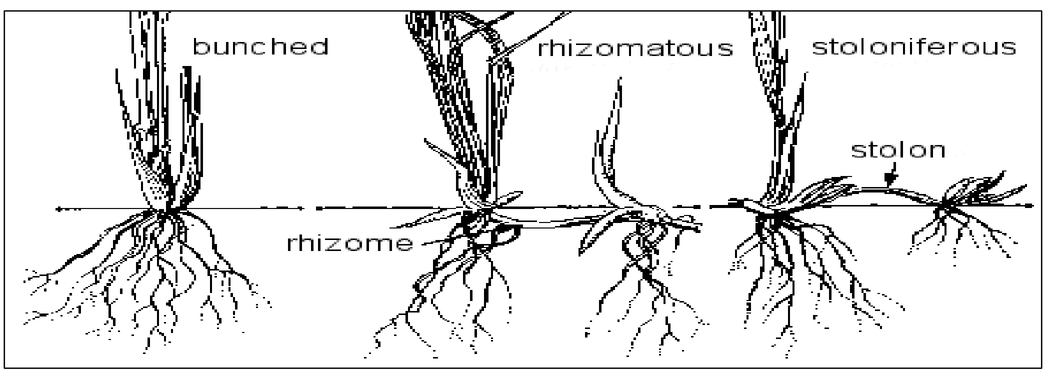


Figure 3.2 The four ways grass grows: bunched, rhizomes, stolons, both rhizomes & stolons.
(www. mb.ec.gc./nature/whp/prgrass/images/df03d00.04.en.gif)

In order for a lawn to survive and thrive, it has to have the right combinations and proportions of the following:

- the proper cultivar for the geographic location

- friable soil (A soil with ideal consistency.) (Decker, 255)
- irrigation, as necessary
- sufficient drainage
- sun or shade as required

Three other factors should be considered: (1) What will its function be- a playing surface or a low-traffic lawn? (2) What level of maintenance is expected- relaxed or manicured? (3) What method of installation- sod, sprig, seed, or hydroseed? Sod yields an instant lawn. The grass is grown on a sod farm and cut from the ground with roots and soil, usually sand, attached. Then it is put on pallets in 2' x 2' squares, 1' x 9' rolls, or rolls of 4' x 100', and shipped out. The huge rolls of sod are laid mechanically; the other types by hand. Sod is more expensive to install than other methods because it is more labor intensive.

Sprigging is the process of planting small, usually 4" x 4" squares, on prepared ground. This is the next best method to use if there is a large area to cover and cost is a concern.

Grass seed can be spread by hand, by a mechanical spreader, or shot out by a high pressure hose, which mixes it with a tackfier, so that it can stick to the ground. Seeding is the least expensive and least reliable way to get grass established. It is, however, the fastest way to cover a very large area.

Initially, a new lawn will need to be watered daily for two weeks for it to take root. Thereafter, it can be programmed on a timer for once-weekly watering. The sprinkler system can be above or below ground. A standard way of irrigating is with pop-up rotors and sprayheads. In recent years, new options have come on the market such as watering via an underground drip matrix system. Most applications of this type of irrigation system have been for golf course greens, as it was designed for short running times in small areas. A unique feature of this underground system is that it can do both watering and fertilizing at the same time.

Assuming that the lawn gets sufficient water, light conditions are right, and excess water drains well from the soil, a stand of grass will begin growing immediately or in a few days. It can be mowed when the grass is rooted and will not come out of the ground when tugged by hand.

The UGA quadrangle lawn contains, for the most part, a stand of tall fescue that is watered by pop-up rotors. That particular species of grass was chosen probably because it tolerates shade from all trees located there. Also, tall fescue makes a tough lawn for recreational use, and its dark green color is attractive. Its one drawback is that it is a bunch grass, and therefore appears tufted up close. Soil compaction and tailgaiting on top of it thins the grass, giving it a sparse look.

SOIL

Without good soil, a lawn will not be healthy. The soil anchors turf, serves as a reservoir for essential elements, water and gases; and insulates its roots against adverse environments such as freezing temperatures (Decker, 1). Soil is a complex physical, chemical, and biological system (Harris et al, 75). According to Cornell University Professors, Nina Bassuk and Peter Trowbridge, soil is vital to plant establishment because it influences so many of the basic factors for plant growth: water, nutrients, oxygen, and its own temperature (Bassuk and Trowbridge, 646).

The soil layers, or horizons, found in a natural, undisturbed site are quite different than soil layers in an urban setting. The horizons are labeled A, B, and C, and R, from the top down. Normally, topsoil constitutes the A and B horizons. C horizon is sub-soil that has just begun to weather, and R is bedrock. Topsoil contains elements and nutrient- rich humus, organic matter, and soil microbes; basic elements which form fertile soil. On sites where buildings have been constructed, blasting or heavy machinery that excavates the ground to lay a foundation mix up the horizons so that construction debris, weathered rock, topsoil, and subsoil are combined en masse.   Simple soil probes and research into the development history of the site can reveal valuable information that must be considered before the design process begins (*Landscape Architecture*, March 1996, 96). Plant sustainability depends on the decision to amend, remove, or berm (mound) on top of the existing soil.

An ideal soil has four major components: mineral materials (45%), organic matter (5%), air (20-30%), and water (20-30%) (Craul, 12). The mineral matter, is divided up by texture, containing varying percentages of sand, silt, and clay particles. Soils with good texture have relatively equal proportions of sand and silt, plus clay; and together with organic matter, form the solid portion of the soil. The pore spaces in a soil's

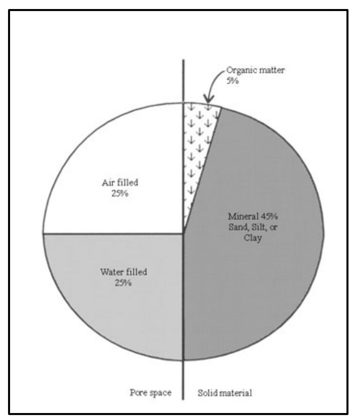


Figure 3.3 Ideal Soil Components (Craul, 12)

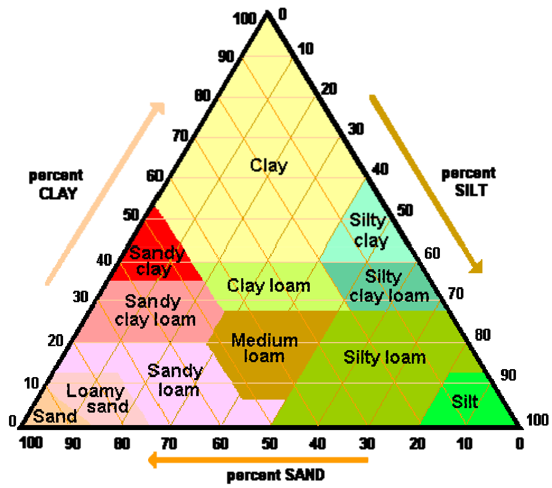


Figure 3.4 The Soil Texture Triangle (www.oneplan.org/Images/soilMst/SoilTriangle.gif)

composition consist of varying amounts of air and water. The small portion of organic matter, including largely decayed humus, consists of the remains of dead plants, animals, and microbes, the living organisms of the soil (Decker, 3).

Besides soil texture, this study focuses on two other factors: soil structure, and bulk density. Soil structure describes how particles are arranged into units called peds, or aggregates (Harris et al, 100). When aggregates are grouped together, they create more large pores called macropores, which are essential for water and air drainage (Bassuk and Trowbridge, 646). A soil with good structure allows air, water, and roots to move easily through it. Also, it drains well and resists compaction.

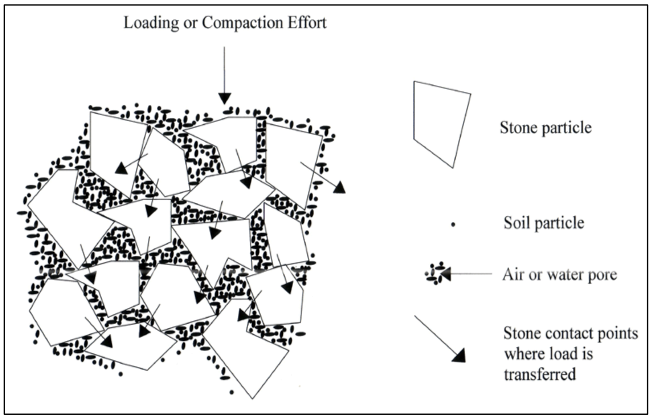


Figure 3.5 The Composition of Structural Soil (Bassuk et al, 2)

A soil's bulk density is another important physical property to determine prior to planting. Bulk density is a measure of the weight of a given volume of soil (Harris et al, 94). To put this into context, soils have bulk densities ranging from 1.0 - 1.4g/cm^3, (normal texture and easy rooting), to 2.0g/cm^3 (brick) and 2.6g/cm^3 (rock) (Ibid, 95). Obviously, plant roots cannot grow in soil volumes that are literally, "thick as a brick."

The Natural Resources Conservation Service publishes *Soil Surveys,* which classify soils in series, dependent on location. For example, the study quadrangle is located in the state of Georgia, in Clarke County, in the city of Athens. Originally, when the *Soil Survey* was published, there was a "CECIL" series of soil, which is characterized as a sandy clay loam. A look at the Soil Textural Chart shows that this particular soil is predominantly clay, but it has some sand and silt particles mixed in. For practical purposes, this soil holds water, compacts easily, and tends to have a high bulk density. (The classification probably has changed since the *Soil Survey* was published, as so much underground work has taken place. Current soil testing will classify the mixture.)

TREES

Trees are an integral part of both urban communities and the ecological systems in which these communities exist (Georgia Model Urban Forest Book, 3). They provide environmental, economic, social, and psychological benefits, which Dr. Kim Coder, a noted tree expert and Forest Resources Professor at the University of Georgia, lists succinctly in one of the many papers he has written for the Georgia Cooperative Extension Service (Coder, Oct, 1996).

I. Environmental Benefits
- A. Temperature and Energy Use
  - 1. Shade
  - 2. Wind Control
  - 3. Active Evaporation
- B. Air Quality
  - 1. Oxygen Production
  - 2. Pollution Reduction

3. Carbon Dioxide Reduction
C. Hydrology
1. Water Run-Off
2. Water Quality/ Erosion
D. Noise Abatement
E. Glare Reduction
F. Animal Habitats
II. Economic/ Social/ Psychological Benefits
A. Economic Stability
B. Property Values
C. Product Production
D. Aesthetic Preferences
E. Visual Screening
F. Recreation
G. Health
H. Human Social Interactions

Clearly, trees influence every aspect of life. They are, however, a valuable resource that is taken for granted. Only with the rapid loss of forest cover associated with urbanization have people realized that there is a sense of urgency to protect what remains, and to create new urban forests that offset the impacts of development (USDA Technical Report, November, 2006, 11).

It takes generations to grow a mature urban forest. Most urban street trees in densely paved settings do not survive beyond seven years because of the terrible conditions that they are subjected to: polluted air, lack of water, compacted soil, animal urine, people climbing on them, and vehicles hitting them. Utility companies cut their canopies from overhead wires, and their roots when installing new infrastructure. However, the single most important requirement for growing large, healthy, and long-lived trees in the urban forest is the quality and quantity of the soil (Georgia Model Urban Forest Book, 20). A tree, which would normally live fifty years or more and grow to a height of 70 feet and a width of 50 feet, cannot be expected to thrive to maturity in a five cubic foot tree pit with constraining soil and a bulk density near 2.0g/cm^3. A tree needs rooting space to grow in (soil volume) that is at least as wide as the drip line from its mature canopy. Even then, the lateral roots will extend far beyond. A rough rule of thumb is to provide two cubic feet (cf) of usable soil for every one square foot (sf) of mature crown projection (area under the dripline) (Grabosky et all, 5). Crown projection can be calculated using the formula for an area of a circle, 3.14 (pi) x radius squared. For example: if a tree's crown is 20 feet in diameter, the radius is ten feet, ten squared is 100; the crown projection would be 3.14 x 100= 314 sf (Ibid, 5). Applying the rule of thumb (2cf/ 1sf) for crown projection would mean 2 x 314sf= 628 cf of soil is needed to support the tree (Ibid, 5).

The above ground parts of a tree depend on roots, for anchorage, absorption of water and mineral elements, and synthesis of certain organic materials, including those that may regulate activities in the top of the plant (Harris et al, 23). The tree's structural roots are mainly within a relatively small area known as the zone of rapid root taper. In this zone, the roots, which are 4-6" in diameter, extend out from the trunk flare approximately six feet and then taper to about 2"; occupying only about 6 – 12" of the soil depth (*Landscape Architecture*, March 1996, 79). Keeping this area free of obstructions is important to long-term tree health, as this is a critical area especially when the tree is young (Urban, 643). Adding mulch around the base of the tree allows absorbing roots to take in air, water, and essential elements. Also, mulch protects the roots from temperature extremes and weed growth.

The table below shows the number and type of trees located in the quadrangle:

Table 3.1 Trees in the Quad

2	PIN OAK	Quercus palustris
4	SHUMARD OAK	Quercus shumardii
7	WATER OAK	Quercus nigra
1	SAWTOOTH OAK	Quercus accutissima
1	WILLOW OAK	Quercus phellos
1	WHITE OAK	Quercus alba
1	TULIP POPLAR	Lirodendron tulipifera
1	CREPE MYRTLE	Lagerstroemia indica
1	AMERICAN ELM	Ulmus parvifolia
4	RED MAPLE	Acer rubrum
3	PECAN	Carya illinoiensis
1	GINGKO	Gingko biloba
1	CRABAPPLE	Malus spp.
1	MAGNOLIA	Magnolia grandiflora

29 total trees

STORMWATER

The fourth component comprising the UGA quad is stormwater. Stormwater is an environmental process, joining the atmosphere, the soil, vegetation, land use, and streams, and sustaining landscapes (Ferguson, 1). It is a process that is as peaceful as rain falling on a lawn and trees and infiltrating into the soil below; or, it is as destructive as torrents of stormwater, picking up pollutants along the way, and dumping them into a nearby stream, causing flooding and water quality problems.

The hydrologic cycle is a continuous system that involves five processes: condensation, precipitation, infiltration, runoff, and evaporation. Condensation forms clouds. Rain falls and it either infiltrates into soil strata or becomes runoff, which moves on to waterways. Stormwater that percolates down to the groundwater, or aquifer, recharges its supply. From there, groundwater slowly discharges clean water into streams to keep base flows (stream flow between rainfall) at a viable level. Finally, waterways reach the ocean, where its seawater evaporates and the cycle begins all over again. Trees, turfgrass, soils, and plants also release water vapor into the air by evapotranspiration.

In a small ecological structure, like the UGA quad, trees, turfgrass, and soil could work in unison to intercept and infiltrate stormwater, filter any noxious elements, and maintain balance in the water cycle. What occurs there now is that during a storm, the rain produces surface runoff due to soil compaction. The thinned lawn enables stormwater to carry away grass seed, fertilizer, and sediment . Because water cannot reach the groundwater, little or no contributions are made to the stream base flow. According to stormwater expert, Professor Bruce Ferguson, treatment and infiltration of only a small runoff amount, when repeated for every small storm and the first flush of every large storm, restores most of a watershed's groundwater, base flow, and water quality (Ferguson, 11).

Yet, urbanization imposes a litany of ruinous effects on the environment. Trees are removed, the soil horizons are disturbed, heavy machinery compacts the soil, erosion occurs on bare areas, the air becomes polluted with fumes and dust, grading changes the natural flow of water, and stormwater turns into runoff, which has its own egregious consequences. One of the most distinctive characteristics of modern development is the enormous amount of land covered over by streets, parking lots, sidewalks and rooftops (Alcovy Watershed Protection Project). Stormwater from these impervious surfaces goes down a drain system, which pipes it out to a nearby stream. Rainfall from all over the watershed reaches the stream at a faster than natural rate, causing increases in the magnitude and frequency of flooding (Ibid). Stormwater management, therefore, is a critical issue.

Porous pavements can help control runoff at the very point where it begins, by allowing rainwater to infiltrate the soil underground. They can even supersede costly stormwater infrastructure and detention ponds. Healthy properly constructed turf is inherently porous and permeable, so it increases stormwater infiltration and reduces runoff (Sawhill, 243). Examples of built projects all over America exist where porous turfgrass has successfully attenuated stormwater. One such project is the parking lot at the Orange Bowl in Miami, Florida, which is covered with porous turfgrass except for the turning lanes. Although there is a drainage system present, for overflows during large storms, the turfgrass allows the rain during almost all storms to infiltrate where it falls.

There are other “green” (eco- sensitive) technologies available that merge the structural and horticultural needs for the urban environment (Dockter, *Land Development Today*, January, 2006). Structural soil, like the one developed at Cornell University, is in that category. Both porous turfgrass and structural soil will be discussed, in the chapters that follow, as possible sustainable solutions to the landscape maintenance problem in the study area.

CHAPTER 4: POROUS TURFGRASS

Porous turfgrass is a lawn that can bear traffic; it is a form of porous pavement. However, unlike all other pavements, it lives, breathes, drinks, and grows. When properly installed over a carefully prepared base, it can be used for pedestrian or very light vehicular traffic. Also, compared to its inert alternatives, asphalt and concrete, porous turfgrass surpasses them in the number of environmental benefits it offers. To recap some of its unique attributes:

- possesses natural beauty
- allows stormwater to infiltrate to the soil below
- filters noxious chemicals
- improves air quality
- reduces erosion, glare, and noise
- counteracts the “heat island” effect
- cushions falls
- reduces costly stormwater infrastructure

The drawbacks of porous turfgrass are:

- needs ongoing maintenance
- not suitable for heavy vehicular traffic
- requires frequent watering especially to get established
- installation is best during spring, summer, or fall
- species selection, light requirements, location are critical

Determining a site’s prospective traffic level is essential to a decision to use turf surfacing, and to the selection of an appropriate variety of grass, soil profile, and reinforcing material (Sawhill, 243). In my opinion, the quad lawn has a pedestrian traffic level equal to that of recreational sports. However, it does not have the proper soil, or reinforcement, to distribute the load it is subjected to. The existing soil is clayey, rock hard when dry, plastic when wet, and not reinforced in any way. In order for this public lawn to be a porous pavement, which is capable of sustaining heavy use and tough wear, changes must be made.

This thesis examines several ways that a porous turfgrass can be installed and function as it was intended in the UGA quad. It focuses on methods for strengthening the soil beneath the lawn: one, gravel based, and the other, sand based with, or without, reinforcing mesh in the rootzone mix. The gravel based, load bearing foundation is called structural soil, and it will be featured in the next chapter. The remainder of this chapter discusses two sand based soil profiles and a reinforcing mesh element for a sandy rootzone.

During the early twentieth century, scientists tried to develop a suitable grass surface to play sports, like golf, soccer, and football, in all kinds of weather conditions. Research conducted at Michigan State University concluded that the key to constructing the "perfect field" lay in the choice of the root zone material (Henderson et al, 2001). Additionally, scientists learned that the two predominant limiting factors to growing turf in high-traffic areas were compaction and drainage (*Turf Magazine*, June, 1998). The quest continued to produce a strong and stable playing surface that did not compact and that drained well.

TEXAS/USGA ROOTZONE

In the early 1950s, The United States Golf Association (USGA) funded research regarding the physical performance of root zones; and, in 1960, published guidelines for selecting and evaluating root zone materials (*Grounds Maintenance Magazine*, June, 2001). Since then, many golf greens and athletic fields have been constructed with sand-based root zone mixes (Waltz et al, 2003). High sand content provides rapid drainage, limits soil compaction, and promotes aeration for root growth. Sand's disadvantage is its inefficiency in retaining moisture and nutrients (Ibid), which will be discussed later in this chapter.

The first high- sand root zone soil mix resulted from the collaboration of the USGA and Texas A & M University; thus, the name Texas-USGA Method. The Texas-USGA soil profile is a series of carefully selected gradations of sand over gravel; the sand particles in each layer sizably larger going from top down. It has a 12" sand based root zone layer over a 4" gravel layer, which is over a 4" drain pipe that is located in a trench in the compacted subgrade. A geotextile fabric is an optional item that can be placed in between the gravel layer and the compacted subgrade. The "choke" or "filter" layer, consisting of 2- 4"of angular coarse sand, can be inserted between the gravel and the root zone (Sawhill, 251). The coarse sand zone has two key functions: (1) To prevent infiltration of the high- sand root

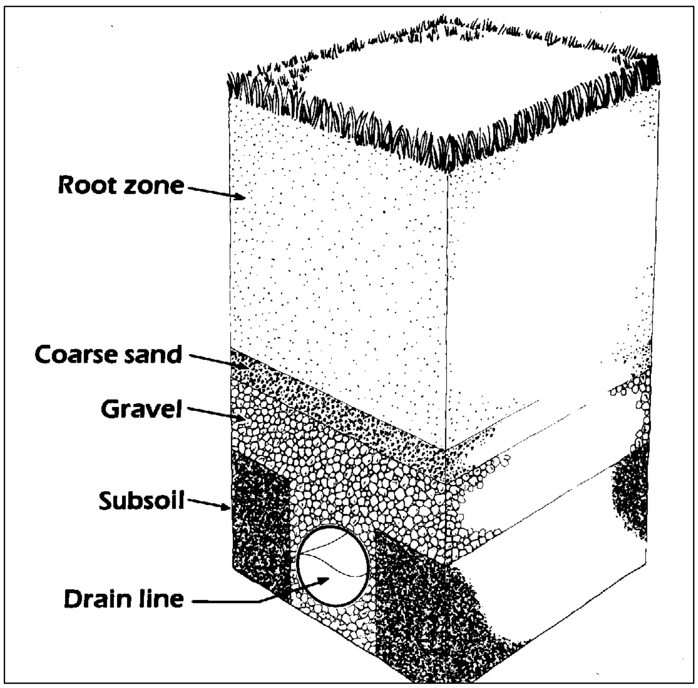


Figure 4.1 TX/USGA Soil Profile (Beard and Sifers, 5)

zone mix into the spaces between the drainage layer particles and (2) To create a perched hydration zone of plant- available water immediately above the drainage layer in the lower portion of the high- sand root zone mix (Beard and Sifers, 5).

The Texas- USGA system is based on the concept known as the perched water table or inverted filter design (*Grounds Maintenance Magazine*, June, 2001). This design uses water's affinity for more finely textured materials to hold ("perch") it in the root zone above coarser gravel (Ibid). As water saturates the sandy root zone layer, gravity forces water to go through the larger voids in the gravel, which were preventing downward flow.

Two problems with using a high- sand- content root zone medium are that sand has poor water and element retention. To compensate for this inadequacy, the USGA specifications call for blending organic or inorganic matter into the root zone medium, so long as the physical requirements for permeability (water movement through the root zone) and porosity (pore space) are met (*Turf Magazine*, June, 1998). Peat moss is an example of the most commonly used organic amendment. Examples of commonly incorporated inorganic amendments are: calcinated clays, diatomaceous earth, and zeolite. Permeability is achieved by the ratio of particle sizes from the sand layer down to the gravel. This difference in size is necessary to create the perched water table effect (*Grounds Maintenance Magazine*, June, 2001). The total porosity requirement for the TX/USGA soil profile is a minimum of 35% after compaction, and a drainage capability of 6" per hour (Sawhill, 253).

CALIFORNIA ROOTZONE

The other high- sand- content root zone mix is named the California, or "straight sand" medium, because it was developed at the University of California. This system consists of 12" of sand over a compacted subgrade. The gravel-encased drain pipe is submerged in a trench in the subgrade, exactly like the Texas-USGA system. Within the sandy root zone layer, sand particle sizes must be larger from the top down in order to create capillary action (movement of water from wet areas at the bottom to drier areas near the top.)

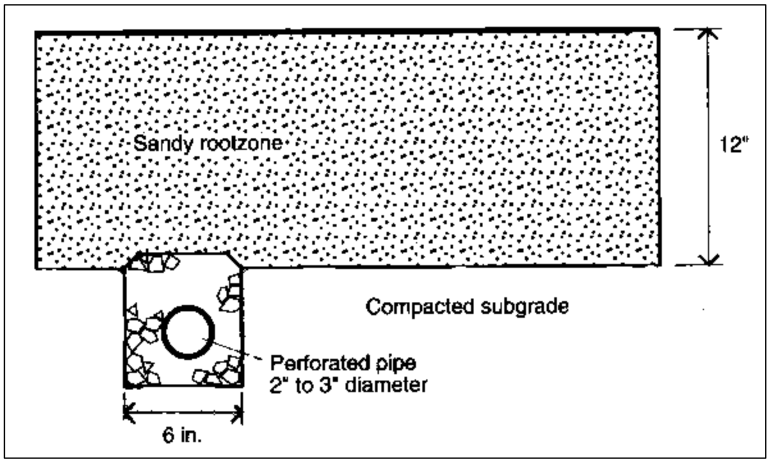


Figure 4.2 California Soil Profile (Sawhill, 252)

The California system is not as costly to install as the Texas-USGA Method because it omits the gravel drainage layer and the choke course. Some shortcuts can be taken to further reduce costs when constructing this soil profile. First, the drain pipe can be removed as long as the subgrade has been sculpted to move water downhill. If the drain pipe is removed, there is no real requirement to put down a gravel layer or a geotextile fabric. Also, the sandy root zone can be cut back to a 6" depth. Lastly, the California soil profile is suitable for sandy soils and the Texas-USGA Method is better for soils with more clay.

Careful scrutiny of the particle sizes is imperative for both the Texas-USGA and the California systems to work properly (capillarity). The Texas-USGA requires that 0 to 20% of the mixture be from the 0.15 to 0.25mm range, and 60- 100% from the 0.25- 1.0mm range; California requires that 82-100% be from the 0.1- 1.0mm range (Sawhill; 252).

REINFORCING ELEMENTS

There are several products that are available for overcoming the shifting and instability of a sandy root zone medium. This thesis, however, concentrates on the integral mesh element produced by the Netlon Advanced Systems company. The mesh is designed to be blended into the sandy rooting medium and compacted. Then, washed sod or grass seed is spread on top. The reinforcing mesh in the root zone prevents rutting and soil compaction, and improves turf resiliency by promoting root density and depth (*Turf Magazine*, June, 1998). In essence, the reinforcement improves the load- bearing capacity of a sandy rootzone.

Figure 4.3 Close-up of mesh element.
Photo by OAM

Netlon Advanced Systems, a British company, markets their products in the U.S. through the Glenn Rehbein Company in Minnesota. Their “Advanced Turf” consists of a 2” x 4” polypropylene mesh the size of a playing card, which is blended in the soil. It forms a durable, stable, yet flexible reinforcement for turfgrass sand. Its flexibility is due to tensile strength (the resistance of a material to a force tending to tear it apart). When a force applies pressure to the grass, the fibers expand to let the weight be distributed evenly and laterally. Afterwards, the grass and soil spring back to their original shape with no residual effects. (Netlon Research Data downloaded from website).

There are many case studies to document Advanced Turf's use in the United States and Europe. The Glenn Rehbein Company, for example, has built two mesh-reinforced turf parking areas in Minnesota and one in Wisconsin. The parking lots are still in good shape after five years of use. Landscape maintenance concentrates on removal of thatch, which can prevent water and air from infiltrating below grade. Other case studies involving Advanced Turf show its use on fire lanes, parking lanes in shopping areas, and as part of a constructed land form sculpture. Netlon recommends Advanced Turf for use in those areas and wherever there is light vehicular traffic.

In the spring of 2007, Advanced Turf was installed around the Convocation Center at the University of South Carolina- Aiken. The photo below was taken in July, 2007, a few months after installation, and one week after the circus and a carnival had set up on the lawn. The grass appears to have held up well and shows no rutting.

Figure 4.4 Advanced Turf at USC-Aiken Photo by OAM

CHAPTER 5: STRUCTURAL SOILS

In the mid 1990s, structural soil was invented at Cornell University's Urban Horticultural Institute and patented for quality control under the name "CU- Soil." It is a two-part system comprised of a rigid stone "lattice" to meet engineering requirements for a load-bearing soil, and a quantity of soil, to meet tree requirements for root growth (Bassuk, et al, 3). The CU-Soil consists of 70- 75% of a homogeneous size, or open graded, angular stone (1" to 4"), with no fine material, that compacts firmly, yet leaves 25- 30% open spaces, or macropores, between the stones for root, air, and water penetration. Although the stone lattice can compact to nearly 100% (Proctor density test reading), the strength of this soil system actually comes from the interlock between the stones, where the angular facets touch one another. Also, the type of rock used for the lattice is very important, as it must be able to sustain pedestrian and light vehicular traffic. In Northern Georgia, crushed and graded granitic rock is used conventionally in pavement base course preparation and is adequate for use in structural soil. Other areas of the country may specify other types of rock aggregate for pavement and structural soil construction.

Surprisingly, soil constitutes only a small portion (25%) of CU-Soil. Too much soil would clog the macropores that are crucial to the viability of CU-Soil. The best soil to use for the CU-Soil system is a clay loam, as it absorbs water and elements and holds them via capillary tension and electrical charge. A look back at the soil textural chart in chapter three shows that a clay loam is a soil that has proportional amounts of sand, silt, and clay; however, the clay portion is slightly higher. As tree roots grow through the pores of the structural soil matrix, they are able to take in the elements and water. Other types of soil can be used in structural soil as long as the soil is tested and contains enough clay and silt to hold water and elements.

The third component of CU-Soil is a small amount (.03%) of Gelscape, a hydrogel polymer that absorbs three hundred times its weight in water. As the hydrogel expands in the CU-Soil mixing process, the soil becomes suspended in the gelatinous material, and the stone matrix gets coated evenly with soil. The end result looks like #57 stone (¾”) that has been smeared with soil and hair gel.

CU- Soil is a product that resulted from years of studying the many stresses that trees endure in urban environments. As explained in the section on trees in chapter three, in urban settings, a young tree is too often planted in a five cubic foot “coffin” and backfilled with poor soil that is void of pores where air, water, and elements can reach the root system. Then, the young tree must absorb polluted air, deal with heat and cold blasts, droughts and floods, and withstand abuses from people, animals, and vehicles. The most significant problem that urban trees face, however, is the lack of useable soil volume for root growth since trees are often an afterthought in streetscape construction (Bassuk, et al, 1). It is no wonder that these street trees have trouble living longer than seven years.

The installation process for the CU-Soil, and soil blends like it, is simple, but it must be done correctly. A critical point is that there must be sufficient space planned for it: a depth of 2 to 3 feet, a width of 4 to 5 feet minimum, and an area at least proportional to the tree canopy at the drip line. In the cases of a tree lawn, it may mean that a sidewalk may have to be broken out and excavated further. For a streetscape, where trees are planted in a row, the structural soil layer should be continuous under the pavement. The life of the urban forest can be extended if enough rooting space can be provided by a retrofit operation or planned at the outset of the project.

The structural soil is applied within a contained area in 6” lifts (layers) around the tree. Each lift is compacted to nearly 100% compressive strength. With its high compressive strength, the CU-Soil will not subside under pedestrian or light vehicular traffic. Once the hole is filled with structural soil, the top can be covered with mulch or a porous pavement, which will allow water to infiltrate to the soil below grade. A drain pipe to remove excess water is encased in a gravel trench in the subgrade.

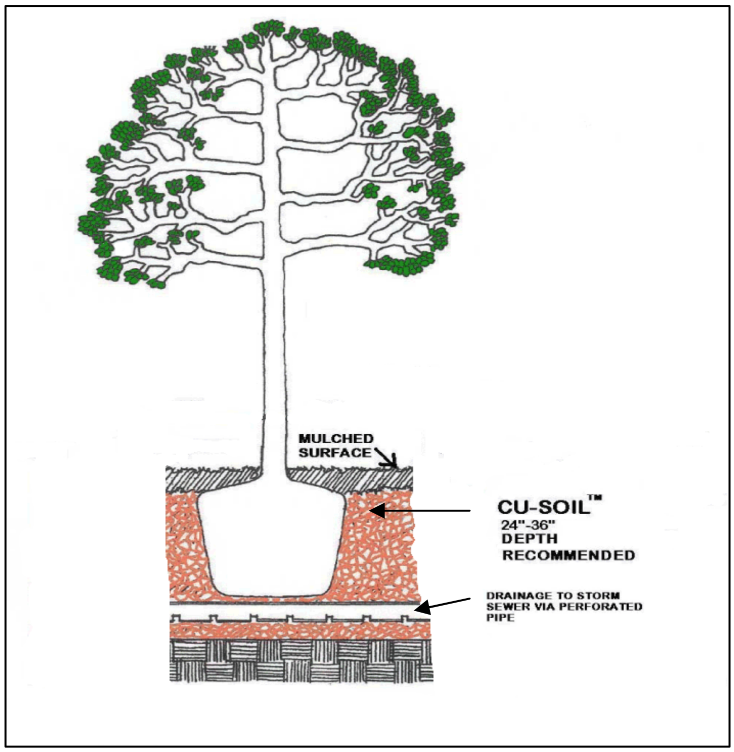


Figure 5.1 Section of Tree in CU-Soil (www.countryviewinc.com/images/tree.gif)

As mentioned earlier, CU-Soil was patented for the purpose of quality control. Its inventors wanted to insure that it would be produced in the same way, every time. It is a custom item that is produced and shipped to a site only when it is ready to be installed. Keeping it exposed, or as a bulk product for a long period, is not recommended. The main licensor for CU-Soil is Amereq, Inc., in New City, New York. In Georgia, Erth Products, in Peachtree City and the City of Athens are licensed by Amereq to produce and sell the patented soil. Furthermore, Erth Products and the Carolina Stalite Company in Salisbury, North Carolina produce their own blends of structural soils similar to the CU-Soil. Both companies have structural soils made with expanded shale as the load-bearing rock. They, too, have a number of installed projects to their credit.

Structural soil can be retrofitted in an area with mature trees by a process of air excavation and radial trenching. If soil compaction is causing a tree to die back, excavating with a high pressure air wand can blow compacted soil off the roots. This process, however, requires patience and care, as roots of an established tree are fragile. Radial trenching resembles a pie sliced into parts. Trenching can begin near the tree’s trunk to a width and depth of 1.5 to 2 feet.

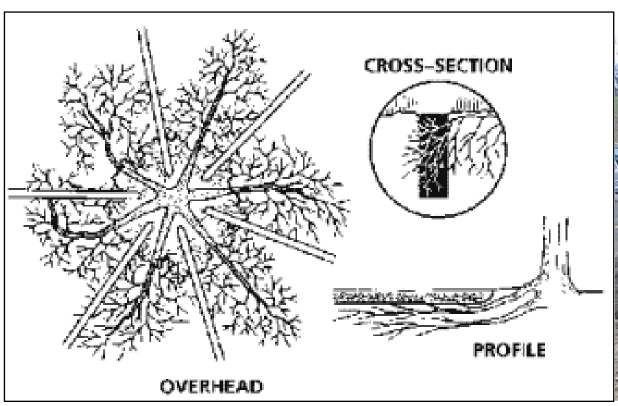


Figure 5.2 Cross-Section of Radial Trenching (www.treehealth.com/trenching.htm)
Figure 5.3 Radial Trenching   (www.treehealth.com/trenching.htm)

The length of the trench will be determined, more than likely, by the proximity of nearby objects.

After the excavation is done, backfilling with structural soil will help trees acquire air, water, and elements. According to Dr. Nina Bassuk, at Cornell University's Urban Horticultural Institute, she has had success with this process when trying to save urban street trees in Ithaca, New York (Structural Soil Class in June, 2007).

CU-Soil was originally designed for use with trees. Now, Cornell University experimental plots clearly show that it is doing well with tall fescue, a cool season grass, and not doing well with zoysia, a warm season grass. (Ithaca, New York is too far north for zoysia.) According to Professors Bassuk and Trowbridge, washed sod was laid on top of the structural soil. The lawn has been in the ground for several months, and has had vehicles, equipment, and pedestrians all over it with no visible effects.


Figure 5.4 Prof. Trowbridge standing on grass grown on CU-Soil, June, 2007. Photo by OAM

Figure 5.5 Tree in CU-Soil Photo by OAM

CHAPTER 6: LANDSCAPE MANAGEMENT

Figure 6.1 Sheep on Lawn (www.whitehouse.gov)

Landscape management practices have come a long way from allowing sheep, cattle, and horses to graze on the grass as a means of maintenance. With the invention of the scythe, a blade with a long handle, laborers could walk the fields, slinging the blades, and cutting fields of grass at a faster rate. In 1830, during the Industrial Revolution, the idea of mechanizing the blade evolved into the invention of the push lawn mower. From that time on, landscape maintenance has grown into a sophisticated multi-billion dollar business, with professional associations, degreed personnel, computer software, complicated mowing machines, time-saving gadgets, literature covering a broad range of related subjects, and even specially built trucks to carry equipment and laborers from job to job. Furthermore, the green industry, as it is often called, employs a wide range of people who have an interest in plant materials, the environment, landscapes, forests, agriculture, and associated fields.

Figure 6.2 Modern Landscape Maintenance (www.elandcare.com)

Figure 6.3 Posts with Banding. Photo by OAM

The University of Georgia has landscape maintenance crews that are responsible for keeping the study area and all the outdoor areas clean, healthy, and safe. They quickly clean up after storms, especially if weak-rooted trees have toppled, or tree branches are in danger of falling. A thunderstorm in the summer of 2006 caused several old oak trees to fall. The crew planted new trees as their replacements.

During the school year, they keep the lawn on the quad cordoned off with two foot tall 4”x4” pressure treated posts linked by tree banding. This is supposed to discourage people from walking on the grass; however, students still take the shortest route between two points to get where they need to go. As a result, there are several paths that have been worn into the grass. During special events like May

Figure 6.4 Tailgaiting on Quad. Photo by OAM

graduation, the fencing is removed, as the lawn is a favorite spot for family pictures and celebrations. The Law School, in particular, holds its graduation ceremony on the lawn of the study quad.

By far, the worst damage to the lawn is done during football season. Tailgaters compete for the privilege of locating their entourage on the quadrangle. Before the game, they set up tents, chairs, concrete UGA bulldog figures, grills, generators, TVs, and any other red and black UGA paraphernalia to “party hardy”. When they depart, the scene looks like a tornado ravaged the place. There is trash strewn everywhere. The grass is matted down from hundreds of people trampling it for two days. Chunks of grass have been uprooted from tent stakes being pulled out. Ruts from heavy use are present.

Figure 6.5 Tailgating Aftermath. **Photo by OAM**

Then, of course, mounds of spent coals and ashes from barbeque pits can be spotted here and there.

After a weekend of tailgaiting on the quad lawn, extra laborers are hired by the university to pick up all the trash. They are paid $10.00/hour (without additional expense for taxes, insurance, etc.)

When the above picture was taken (September 2, 2007) there were six people working on trash pick-up in the quad. If they worked an estimated four hours, UGA paid them $240.00. Expenses for Porta-Potties, dump fees, and extra police protection would be additional. This football season, there are seven home games. The aftermath of tailgating on the quad will be more soil compaction and destruction of the lawn and trees. As of mid September, 2007, two trees are dead in the quad. Soil compaction caused by tailgating coupled with the lack of irrigation or stormwater probably killed these trees. Other trees, too, are showing signs of decline.

On the Monday after a home game, the maintenance crew goes to work on measures to revive the grass until the next home game. They may run the core aerator around the quad to relieve soil compaction, spread sand in rutted areas, or sprinkle grass seed in bare spots.

Mr. Mike Orr, chief of the maintenance crews and campus arborist, schedules normal lawn maintenance to be done every week during the months of September to November and from March through May, depending on rainfall. The grass is normally cut at a height of 4”, as cutting it too short would stress it and make the grass vulnerable to disease. Watering, too, would be done on a weekly schedule or when the grass shows signs of stress. Since May of this year, however, Georgia has experienced the worst drought in history. Due to water-use restrictions, irrigation was at first reduced and then banned.

An ordinary maintenance job consists of mowing (via commercial riding mowers), string trimming, and blowing off the area. The extras include edging, spreading mulch around trees and plant beds twice a year, planting annuals in the President's Garden twice a year, putting down a fertilizer twice a year, cleaning up storm damage, planting trees, doing repairs on the sprinkler or drainage systems, and blowing off the area for special events.

A landscape crew consists of three people: a crew chief, a skilled laborer, and a general laborer. Their hourly rate is billed at $25/hour each, or $75.00 for the crew as a whole. Included in that rate is their base pay, taxes, insurance, uniforms, equipment, and vehicle use. Since the crew works an eight hour day, $75.00 x 8= $600.00/day. The author estimated maintenance on the quad to take 4 hours per visit. (Appendix D estimates the impact on UGA maintenance per year.)

PLANT HEALTH CARE

The goal of tree care and landscape management is healthy and safe plants (Harris et al, 501). Healthy plants are able to ward off pests and harmful maintenance practices. The term for this approach to landscape management is plant health care (PHC). It is the evolution of an older practice called integrated pest management (IPM), which focused on eliminating plant pests. PHC focuses on maintaining turfgrass, shrubs, and trees so that they can function as the designer intended or as a natural, healthy ecosystem. It requires a broad array of knowledge: landscape cultural practices, soil properties, tree physiology, plant biology, landscape chemicals, plant pests, and non-living factors that could be harmful to a single plant, or the landscape as a whole (climate, signs of tree decline, turfgrass stressors, and factors leading to plant failure.) In practice, for example, a maintenance manager might survey the whole landscape once a week. If a tree branch is dead, the potential for structural failure is removed, as it might cause injury if it fell. If the turfgrass near the tree is dying, the manager investigates a broad range of causes beginning with the soil and ending perhaps with removal of tree branches to allow more sunlight. All possible solutions are reviewed to remedy the problem and sustain the landscape.

CHAPTER 7: PROPOSAL FOR THE QUAD

The quad turfgrass is a public lawn. It was designed for public use as well as for aesthetic appeal. However, public use is destroying both the aesthetic appeal and the public usability.   Additionally, there are currently some landscape management issues to resolve. Should destructive, heavy public use be continued at the expense of the university's landscape, its maintenance costs, and compromises with those land uses? Should the university limit certain activities, particularly tailgating, in order to keep the soil from compacting, and the lawn and the trees from dying, and preventing stormwater erosion? Or, if the university continues to allow tailgating on the quad lawn, should it make necessary improvements so that public use and public lawn can co-exist?   What improvements could be made and how expensive would they be?

There is no question that something needs to be done to the quad lawn in order to accommodate public use successfully. The aftermath of tailgaters, after the first home game, is atrocious. The lawn is almost completely gone.   After the seventh home game, the effects on the lawn, or what is left of it, and the soil, and the trees will be costly and time consuming to repair.

There are possible technological solutions that have been presented in earlier chapters, to remedy the situation. The remainder of this chapter will discuss possible, viable options for the quad and their pros and cons.

It is possible to perform a one-time or incremental retrofit operation in the UGA quadrangle. An incremental retrofit operation is more costly than the ten day installation project outlined in Appendix A. This opinion is based on the author's 15 years experience as a landscape contractor and business owner. Once the project is scheduled and the personnel and the time allocated for it, it is best to proceed forward. Doing a project piecemeal would be an arduous task; but, nonetheless feasible. Usually, this process incurs more labor and equipment rental costs.

The first step is eliminating the compacted soil. A backhoe could be used in open areas, but for the most part, air excavation would be required to blow the

Figure 7.1 Air Excavated Roots (Bassuk et al, 9)
Figure 7.2 Close-up of Roots Photo by OAM

soil off the tree roots. The University maintenance crew owns an air excavator and is experienced with using it. Around the trees, the crew would need to practice some reinvigoration to keep them stable and to prevent too many roots from being exposed. Afterwards, the excavation site could be backfilled with a new soil mix.

Two different types of soil can be considered as suitable for soil replacement. One is the CU-Soil and the other is the high sand content rootzone with the mesh elements mixed in. The case for each of these systems follows.

A CASE FOR CU-SOIL

CU-Soil is recommended for the quad. The patented CU-Soil would be an excellent choice for soil replacement for many reasons. (1) The expectation of receiving the same product quality with every shipment would be guaranteed. (2) The gravel “lattice” can withstand the heavy weight and wear that the quad lawn gets during tailgate season and throughout the academic year. (3) The CU-Soil would not shift or become unstable once tamped in place. (4) The tree roots would be able to grow through the pores in the gravel easily. (5) This soil was first designed for use with trees. (6) The turfgrass roots would be able to grow deep and dense, which would allow for quick regeneration. (7) Permeable sidewalks could be laid over this soil. (8) It can support light vehicular traffic. (9) It would be easier to install than the sandy rootzone mix. (10) Essential elements would not be lost as quickly as in sand. (11) Water would be retained better at the upper portion of the soil profile, unlike in a sandy rootzone. (12) Landscape maintenance would be less with this profile, as it would not require frequent soil testing to check on element loss, less dethatching, and no core aeration. (13) This soil probably requires less irrigation because the hydrogel component retains water. (14) It allows stormwater infiltration and treatment of noxious chemicals. (15) It can eliminate costly stormwater infrastructure on new installations. (16) When the new sod on top of the CU-Soil is ready to be walked on (10- 14 days), then a working system is in place for many years. (17) Demonstrations at Cornell University indicate that a smooth, continuous lawn surface is possible.

The drawback with the CU-Soil is that it would have to come out of Erth Products in Peachtree City, Georgia, as that is the closest distributor. Peachtree City is 100 miles, or a two hour drive, from Athens. However, it is possible for UGA to become a licensee in order to install the CU-Soil on university projects. The Operations Manager for Amereq Inc., Brian S. Kalter, outlined the process. First, there would be some administrative and legal paperwork to file plus a one-time fee of $300 to pay Amereq, Inc. After UGA started producing its own soil, it would have to pay quarterly royalties of $1.80/cubic yard of total yards made. Then, people could be trained as quality control officers and could supervise the mixing of the products that makeup CU-Soil correctly (Personal conversation, September, 2007). Mr. Kalter estimated that becoming a operating licensee could be done in several months (Ibid). Then, UGA would be in a position to mix, test, and install its own CU-Soil, using local materials without significant transportation costs. The establishment of this program at UGA would be an investment that would be applied in future years in many areas of UGA's large campus.

A CASE FOR A SANDY ROOTZONE WITH MESH

A sand rootzone soil profile shares some of the positives of CU-Soil. It resists compaction, enables aeration and infiltration, encourages turfgrass roots to grow deeper and denser, attenuates stormwater, supports light vehicular traffic, and can be used emergency vehicle lanes. Also, the soil's porosity and permeability are almost identical. The one major difference is the mesh elements in the sandy rootzone cause the ground to spring back when a heavy load travels across it; and, the spring action provides a soft cushion for a fall. On playing fields, this is an important factor.

The mesh enhanced sandy rootzone has its drawbacks. Its installation is a little more complicated because of the “reverse” rototilling that is needed with a special machine that Rehbein Solutions has to blend the mesh and sand into the ground. Also, it is better suited for an open field with no trees. Its application with trees rooting in the same rootzone with turf has not previously been tested or demonstrated; tree roots could cause some sand shifting. The mesh elements, which form a three dimensional structure underground, may possibly act as a barrier and cause the roots to be deflected and stunted.

Normally it takes two to five years for a high sand content rootzone to become fully stabilized on a golf green. (Turf magazine, June 1998) Using a warm season or a cool season turfgrass makes the difference in establishment. A warm season grass grows and fills in faster (2 to 3 years) than a cool season grass (3 to 5 years) (Ibid).

There is more maintenance involved with turfgrass over a sandy rootzone. Soil testing, fertilizing, and irrigation need to be done on a frequent basis. The results of soil testing dictate what fertilizer needs to be added to replenish leached elements. A sandy profile will tend to lose more water (evapotranspiration), especially on a hot, sunny day. Therefore, more irrigation will be needed to keep the turfgrass from wilting. Lastly, yearly dethatching and core aeration are important in order to keep thatch from building up. Thatch will prevent water, air, and nutrients from infiltrating the soil strata.

GRASS FOR THE LAWN

Tall fescue inhabits the quad now, as it tolerates shade and it can withstand a fair amount of wear. If the quad is retrofitted with CU-Soil, then a washed or bare-root, shade tolerant sod would be best over it. A barerooted sod helps bridge the interface between sod and soil. The turfgrass roots adhere to the soil quickly and the lawn would be established faster. The closest sod farm to UGA that sells washed sod is Jennings sod farm, which is approximately three hours away. Jennings sells a variety of grass called “Atlanta Blend Fescue” and “Empire Zoysia” – two possible choices for the quad. (A UGA turf specialist should be consulted as to which one would be best to use.)

The UGA Turfgrass Institute in Griffin, Georgia, is doing some testing with several different varieties of turfgrasses that may be more appropriate for this situation. While visiting that facility in July, 2007, I had an opportunity to talk to Dr. Clint Waltz, Extension Turfgrass Specialist, who showed me a shade garden where varieties of Bermuda, Centipede, Zoysia, and St. Augustine were being tested for their degree of shade tolerance. The only drawback is that availability of suitable grasses for sale may be some time in the future.

Ideally, the best time to install the sod and CU-Soil would be during the winter break between fall and spring semesters, which would be after December graduation and well before May graduation. As long as the ground is not frozen, there is no fear that the sod would be damaged. Some precautions, however, would have to be considered for excavated tree roots. Watching for adverse weather conditions and exposing the tree roots to cold temperatures for too long could be detrimental. Therefore, it is recommended to install CU-Soil and sod over the air excavated trench as soon as possible.

Another recommendation for the quad concerns the sidewalks and paths, which are more appropriately termed “desire lines.” These paths have been etched into the grass by students desiring to go from one entrance into the quad to buildings on the opposite side. In 1989, Professor Marguerite Koepke, a professor in the School of Environmental Design, published a report that studied, among other things, the paths that students were taking in the quad. Now, nearly 20 years later, students are still traversing the lawn via those same paths. Professor Koepke drew a proposed plan for new sidewalks. It is included as Appendix B in this thesis. Historic Preservationists probably would not want Professor Koepke’s plan installed; but, from a functional perspective, those sidewalks work. Only one thing would be better: constructing the new and reconstructing the old sidewalks out of a porous pavement capable of withstanding the weight of delivery and maintenance vehicles. CU-Soil could be used as the foundation. This installation would have several benefits: (1) This construction technique offers a green solution to the problem of soil compaction. (2) Air and water would be accessible to turfgrass and tree roots. (3) The trees would survive longer in this growing area. (4) Fewer tree fall during storms may be possible due to more vascular root systems. (5) If concrete paver bricks are used for the sidewalks, repairs to underground infrastructure could be done without the use of a concrete saw or jack hammer. (6) Repairs would not be visible if the concrete pavers are used. (8) A significant amount of stormwater could infiltrate to the ground below immediately. (9) This could reduce runoff to stormwater conveyances in this area. (10) Money would be saved in the long run.

Appendix A provides data on estimated costs to install the tandem soil and turf. A quick summary of those costs are: (1) the CU-Soil trucked in from Erth Products in Peachtree City and sod installation is $4.00/ sf; (2) the UGA-made CU-Soil and sod installation is $3.30/ sf; and (3) the sandy rootzone with mesh elements and sod is $3.65/sf. Aside from basic facts and figures, which are definitely important deciding factors for taking on a project, there is the question of making an environmentally correct decision. At the 2006 ASLA (American Society of Landscape Architects) Convention, there was an entire session devoted to the merits of partnering permeable pavements with structural soils in order to improve the urban environment. The experts presenting the session highlighted an important point: "Constructing porous pavements and tree rooting zone media together brings to almost any site the promise of clean water, long-lived trees, and reduced stormwater management costs." (Session SUN-A4, ASLA Conference, October, 2006) Numerous case studies from different regions of the U.S. were recounted to prove their point.

Since the University of Georgia is home to the School of Environmental Design, which educates future landscape architects, it should strive to exemplify teaching and method. The decision to use products which help the urban forest grow and that prevent pollutants from reaching neighboring streams should come first and foremost.

In the perspective of the public lawn, where public use must be accommodated, there is a design flaw that needs utmost attention. Years ago, when there were not so many people on campus using the quad, the public lawn was sustainable. Now, as this thesis has shown, that is no longer the case. In order to make the public lawn viable and sustainable once again, the soil must be changed. It is the key element in this ecological structure. Choosing to install CU-Soil with porous turfgrass is an environmentally correct decision. The money that is spent for installation should be recouped within three years. (Appendix D itemizes the cost savings.) Generations should be able to enjoy the new public lawn.

CHAPTER 8: CONCLUSION

This thesis identified a problem with one of the main quadrangles on the campus of the University of Georgia. However, the implications of this single case study could affect any public lawn. Soil compaction has been the primary cause of turfgrass and tree dieback. Graduation and tailgating during home football games at UGA are the two main, recurring events that have led to the soil compaction. As a result, the landscape maintenance crew have performed their usual recuperative techniques and then put up banding to keep people off the lawn. During the long periods between events, for the most part, this public lawn could be looked at, but not touched. So, the question was what could be done to the lawn to make it more sustainable, resilient, durable, and usable? What would it cost to do this?

After estimating the cost for the UGA crew to install 12” of the CU-Soil with sod surfacing, and getting a quote from Rehbein Solutions to install 8” of the mesh- reinforced sand mix with sod, it is apparent that the first option is more cost effective than the second option. ($3.30 for 12” versus $3.65 for 8”) Furthermore, Mr. Kelly, from Rehbein Solutions, was somewhat skeptical about retrofitting in an area that has established tree roots of mature trees. Therefore, it can be concluded that CU-Soil is the more favorable choice for retrofitting in the quad. (See Appendix A).

Furthermore, in order to save a little more money, the university should inquire about becoming an Amereq licensee for CU-Soil. UGA could not sell to the public; but, it would have the capability to put CU-Soil in future landscape projects. This would mean some cost savings on future projects by reducing the number of stormwater conveyances. Irrigation expenses would be reduced, once the turfgrass is established, because hydrogel retains water. Trees would not have to be replaced as often due to failure from compacted soil. Landscape maintenance, too, would be less because the landscape would be healthier. The maintenance crew probably would be the biggest supporters for the installation of a permanent system; a lawn that they do not have to spend so much time reviving during the fall semester. Public use would no longer compact the soil with year-round use. Lastly, with porous turfgrass and CU-Soil in place, the lawn of yesteryear, instead, would be a sustainable public lawn for the twenty-first century.

BIBLIOGRAPHY

Adams, Dexter. "Uga Campus Landscape Architect." Athens, GA, 2007.

Amereq, Inc. Support Your Local Tree: Cornell Structural Soil Mix. Amereq, Inc., New York, NY, 2004.

Arnold, Henry F. Trees in Urban Design. New York, NY: Van Nostrand Reinhold Company, 1980.

Bachtle, Edward R. "The Rise of Porous Paving." Landscape Architecture 1974: 385-87.

Bassuk, Dr. Nina. "Urban Horticulture Institute, Cornell University." Ithaca, NY, 2007.

Bassuk, Nina, Jason Grabosky, and Peter Trowbridge. Using Cu-Structural Soil in the Urban Environment. Ithaca, NY: Cornell University, 2005.

Bassuk, Nina; Peter Trowbridge. "Soils: Urban or Disturbed." Landscape Architectural Graphic Standards. Ed. Leonard J. Hopper. Hoboken, NJ: John Wiley & Sons Inc., 2007. 646-52.

Beard, James B. and Samuel L. Sifers. Stabilization and Enhancement of Sand-Modified Root Zones for High Traffic Sports Turfs with Mesh Elements: A Randomly Oriented, Interlocking Mesh Inclusion System. College Station, TX: Texas Agricultural Experiment Station, Texas A & M University, 1993.

Beiswanger, William L. "Thomas Jefferson." American Landscape Architecture: Designers and Places. Washington, DC: Preservation Press., 1989.

Ed. William H. Tishler. Building Watcher Series. Washington, DC: The Preservation Press, 1989.

Boney, F.N. A Walking Tour of the University of Georgia. Athens, GA: University of Georgia Press, 1989.

Brede, Doug. Turfgrass Maintenence Reduction Handbook: Sports, Lawns, and Golf. Chelsea, MI: Ann Arbor Press, 2000.

Brown, Walter. Sustainable Design, Construction, and Land Development: Guidelines for the Southeast Atlanta, GA: Southface Energy Institute, 2000.

Coder, Dr. Kim D. "Identified Benefits of Community Trees and Forests." Ed. Forest Resources: University of Georgia, 1996. 1-5.

Commission, Georgia Forestry. Georgia Model Urban Forest Book. Atlanta,GA: Georgia Forestry Commission, 2001.

Companies, Glenn Rehbein. " Netlon Turf Systems". Minneappolis, MN, 2007. web site. Glenn Rehbein Companies.

Craul, Phillip J. Urban Soil in Landscape Design. New York, NY: John Wiley & Sons, Inc., 1992.

---. Urban Soils: Applications and Practices. New York, NY: John Wiley & Sons, Inc., 1999.

Decker, Henry F. and Jane M. Decker. Lawn Care: A Handbook for Professionals. Englewood Cliffs, NJ: Prentice Hall, 1988.

Dober, Richard P. Campus Planning. New York, NY: Reinhold Book Corporation, 1968.

Dockter, Dave. "A Green Building Technique for Infrastructure Planning." Land Development Today 2006.

Dreelin, Erin A., Laurie Fowler, and Ronald C. Carroll. "A Test of Porous Pavement Effectiveness on Clay Soils During Natural Storm Events." Water Research 40.4 (2006): 799-805.

Elmendorf, William, Henry Gerhold, and Larry Kuhns. A Guide to Preserving Trees in Development Projects. University Park, PA: Penn State University. College of Agricultural Sciences. Cooperative Extension, 1999.

Ferguson, Bruce K. Introduction to Stormwater: Concept, Purpose, Design. New York, NY: John Wiley & Sons, Inc., 1998.

Ferguson, Bruce K., Peter Trowbridge, Nina Bassuk, David R. Smith, and Jay Rients. "Permeable Pavements and Structural Soils: Partner Technologies for Urban Environment and Urban Design." ASLA. Minneappolis, MN: ASLA, 2006.

Ferguson, Bruce K. Porous Pavements. Integrative Studies in Water Management and Land Development. Boca Raton, Fla.: Taylor & Francis, 2005.

Ferro, Sam, and Duane Otto. "Drainage Problems? Sand-Based Rootzones Help Golf Courses and Athletic Fields Find "Soil Solutions"." Grounds Maintenance 2001.

Georgia, The School of Environmental Design. The University of. Land Development Provisions to Protect Georgia Water Quality. Atlanta,GA: Georgia Department of Natural Resources Environmental Protection Division, October, 1997.

Grabosky, Jason, Dr. Nina Bassuk, Laura C. Knutson, P.E., and Greg Yoko. "Growing Trees in a Cement Forest." Land Development Today.March (2003).

Grabosky, Jason, Nina Bassuk, and Peter Trowbridge. Structural Soils: A New Medium to Allow Urban Trees to Grow in Pavement. Washington, DC: ASLA, 2002.

Guedes, Pedro, ed. Encyclopedia of Architectural Technology. New York, NY: McGraw- Hill Book Company, 1979.

Hammatt, Heather. "First Impressions: Landscape Architecture Has a Role to Play as Many Universities Face Increased Competition for Incoming Students." Landscape Architecture 2001: 63-69,94-95.

Harris, Richard W., James R. Clark, and Nelda P. Matheny. Arboriculture: Integrated Management of Landscape Trees, Shrubs, and Vines. 4th ed. Upper Saddle River, NJ: Prentice Hall, 2004.

Henderson, J.J., J.R. Crum, T.F. Wolff, and J.N. Rogers,III. Athletic Field Root Zone Mixes: What Is the Best Mix for Your Field? East Lansing, MI: Department of Crop and Soil Sciences, Michigan State University, 2001.

Hopper, Leonard J., ed. Landscape Architectural Graphic Standards. Hoboken, NJ: John Wiley & Sons, Inc., 2007.

Inc., Public Technology. Sustainable Building Technical Manual: Green Building Design, Construction, and Operations. Washington, DC: Public Technology, Inc., 1996.

Jenkins, Virginia Scott. The Lawn: A History of an American Obsession. Washington, DC: Smithsonian Institution Press, 1994.

Johnson, Carol R. "Campuses." Landscape Architectural Graphic Standards. Ed. Leonard J. Hopper. Hoboken, NJ: John Wiley & Sons, Inc., 2007. 754-57
.

Kalter, Brian S. "Operations Manager, Cu-Soil, Amereq, Inc." New City, NY, 2007.

Kelly, Mike. "Vice President, Operations, Rehbein Solutions." Minneapolis, MN, 2007.

Koepke, Marguerite. The University of Georgia North Campus Landscape Plan. Athens, GA: UGA, 1989.

Luman, Stuart. "The New Vogue? Sod." On Earth 23.3 (2001): 7.

Mayer, Eugene. "Compaction Resistance and Drainage: The Driving Force Behind Sand Based Root Zones." Turf Magazine 1998.

McPherson, E. Gregory, James R. Simpson, Paula J. Peper, Shelley L. Gardner, Kelaine E. Vargas, Scott E. Maco, Qingfu Xiao. "Piedmont Community Tree Guide: Benefits, Costs, and Strategic Planting." Ed. Center for Urban Forest Research: USDA Forest Service, 2006.

Newton, Norman T. Design on the Land: The Development of Landscape Architecture. Cambridge, MA: Harvard University Press, 1971.

Nichols, David B. "Comparing Grass Pavers." Landscape Architecture 1995: 26-27.

O'Malley, Penelope. "Maintaining Turf on Golf Courses and Playing Fields: Management Is the Key to Combating High Traffic and Overuse." Erosion Control 2001: 80-85.

Orr, Mike. "Chief, Uga Grounds Maintenance." Athens, GA, 2007.

Rocky Mountain Institute, Alex Wilson, Jenifer L. Uncapher, Lisa McManigal, L. Hunter Lovins, Maureen Cureton, William D. Browning. Green Development: Integrating Ecology and Real Estate. New York, NY: John Wiley & Sons, Inc., 1998.

Sawhill, Ronald B. "Porous Turf." Porous Pavements. Boca Raton, FL: Taylor & Francis, 2005.

---. "Turf." Landscape Architectural Graphic Standards. Ed. Leonard J. Hopper. Hoboken, NJ: John Wiley & Sons, Inc., 2007. 705-12.

Schueler, Thomas R. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban Bmps. Washington, DC: Washington Metropolitan Water Resources Planning Board, 1987.

Shearman, Robert. "Managing Intensively Used Turfs." University of Nebraska Center for Grassland Studies Newsletter 1999: 2-5.

Sipes, James L., and John Mack Roberts. "Grass Paving Systems." Landscape Architecture 84.#6 (1994): 66-69.

Sloan, John J. and Mary Ann Hegemann. "Dual Function Growth Medium and Structural Soil for Use as Porous Pavement." Urban StornWater: Enhancing Programs at the Local Level. Chicago,IL: U.S. Environmental Protection Agency, 2003.

Sorvig, Kim. "Porous Paving." Landscape Architecture 83.#2 (1993): 66-69.

---. "Soil under Pressure." Landscape Architecture 2001: 36-43.

Spooner, David. "Campus Design for the Net Generation." College Planning & Management June 2006: 54-59.

Staff, U.S. Golf Association (USGA)Green Section. Usga Recommendations for a Method of Putting Green Construction. Far Hills, NJ: U.S. Golf Association (www.usga.org), 2004.

Teyssot, Georges, ed. The American Lawn. New York, NY: Princeton Architectural Press, 1999.

Thompson, J. William and Kim Sorvig. Sustainable Landscape Construction: A Guide to Green Building Outdoors Washington, DC: Island Press, 2000.

Tichy, Joe. Impervious Surface Limits, Appendix A. Athens, GA: UGA Northeast Georgia Regional Developmental Center, 1999.

Tourbier, Joachim, and Richard Westmacott. Water Resources Protection Measures in Land Development- a Handbook. Newark, DE: Water Resources Center, University of Delaware, 1974.

Trowbridge, Peter. "Professor, Landscape Architecture, Cornell University." Ithaca, NY, 2007.

Trowbridge, Peter J. and Nina L. Bassuk. Trees in the Urban Landscape: Site Assessment, Design, and Installation. Hoboken, NJ: John Wiley & Sons, Inc., 2004.

Urban, James. "Room to Grow." Landscape Architecture 86 (1996).

Waltz, Freddie C., Jr., and Lambert B. McCarty. "Field Evaluation of Soil Amendments Used in Rootzone Mixes for Golf Course Putting Greens." International Turfgrass Society Research Journal 10 (2005).

Waltz, Freddie C., Jr., Virgil L. Quisenberry, and Lambert B. McCarty. "Greens Management: Physical and Hydraulic Properties of Rootzone Mixes Amended with Inorganics for Golf Putting Greens." Agronomy Journal 95 (2003): 395-404.

Watson, Donald, Alan Plattus, Robert G. Shibley, ed. Time Saver Standards for Urban Design. New York, NY: McGraw-Hill, 2003.

APPENDIX A: COST ESTIMATE

This cost estimate is based on UGA personnel doing the work (air excavating, putting down soil replacement, sod, and clean-up.)

TOTAL WORKABLE SQUARE FOOTAGE (SF): **37,000sf**
This figure was derived by taking the entire SF and subtracting sidewalk SF & a 6' diameter around all trees, valve boxes, & fixtures

TIME ALLOTTED FOR WHOLE JOB: (4 wks); 20 working days (**160 hrs**)
***The 160 hour figure is based on my 15 year experience as estimater for my own landscape construction company, The Built Landscape, inc.

LABOR: 3 people @ $25/hr each= $75/hr x 160 hrs= **$12,000.00**
(labor price includes base pay, insurance, taxes, & equipment)
equipment includes: the transportation to get to & from the site, digging implements, blower, & uniforms

EQUIPMENT / RENTAL:
air spade: NA (UGA owns)
generator: $100/day x 12= **$1200.00** (Rental companies charge for Sat & Sun)
1 month rental **$2500.00** (cheaper to rent by the month)
bobcat (skid steer loader)= **$1500** (I month rental if UGA does not own)
safety equipment: (fences, respirator, ear, eye, & hand protection, signs) **$500.00**

OTHER:
gas: diesel $50/day x 20= **$1000.00** (for dump truck & generator)
dump fees: (**for the useless soil & debris**)= NA (if UGA can dump somewhere)
the landfill charges $45/ton= **$99, 900**

Landfill charge derived by:	37,000 sf
remove 12"	x 1'
	37,000 cu ft (cf)
unit weight of clay	x 120 lb/cf
	4,440,000 lbs /2000 lb= 2,200 tons x $45/ton

Washed sod= $.50/sf x 37,500sf + 7% tax= **$19,795**

MATERIALS:

CU-SOIL from Erth Products (**product trucked from Peachtree City to UGA**):
$62.75/cubic yard x 13 cyds (tandem truck load)= **$815.75/load**

for 2'= $4.98/sf (211 loads)= **$184,171.88** (prices include 7% tax)

for 1'= $2.48/sf (105 loads)= **$91,649.51** (prices include 7% tax)

ERTH PRODUCTS PRICE TO INSTALL 12"CU-SOIL/ SOD

LABOR	12,000
GENERATOR	2,500
BOBCAT	1,500
SAFETY	500
DIESEL	1,000
LANDFILL DUMP FEE	**99,900*****
12" CU-SOIL	91,650
WASHED SOD	19,795
	$228, 845
+ 5% management fee	**$11,443**
SUB TOTAL	**$240,288**
+10% of total figure (Contingency Factor)=	**$24,029**
JOB TOTAL=	**$264,317**
/ 37,000 SF	**$7.10sf**
Without dump fee	**$4.00sf**

JOB USING NETLON MESH ELEMENTS:

MATERIALS:

1 bale of mesh (44lbs) covers 5 cubic yards			**$400/bale**
for 4" sand/mesh mix yields	400sf	(93 bales)	**$39,804*** **
for 6"	300sf	(124 bales)	**$53,072*** **
for 8"	200sf	(185 bales)	**$79,180*** **

Mike Kelly of Rehbein Solutions quoted price of mesh bale & yields (Personal communication, September, 2007)

PRICE OF 8" SAND/ MESH ROOTZONE

LABOR	12,000
GENERATOR	2,500
BOBCAT	1,500
ROTOTILLING ATTACHMENT	500
SAFETY	500
DIESEL	1,000
LANDFILL DUMP FEE	**99,900*** **
8" SAND/MESH MIX	79,180
WASHED SOD	19,795
	$216,875
+ 5% management fee	**$10,844**
SUB TOTAL	**$227,719**
+10% of total figure (Contingency Factor)=	**$22,772**
JOB TOTAL=	**$250,491**
/ 37,000 SF	**$6.77sf**
Without dump fee	**$3.65sf**

IF UGA COULD PRODUCE ITS OWN CU-SOIL

According to Dr. Bassuk, in an article written in *Landscape Architecture* in 2001, the price to produce CU-Soil was $40/cubic yard (cy) (Landscape Architecture, June, 2001, 42). Now, six years later, and accounting for inflation, I am assuming that the price is now $50/cy. This price does not include what it would cost to become a licensee. Therefore:

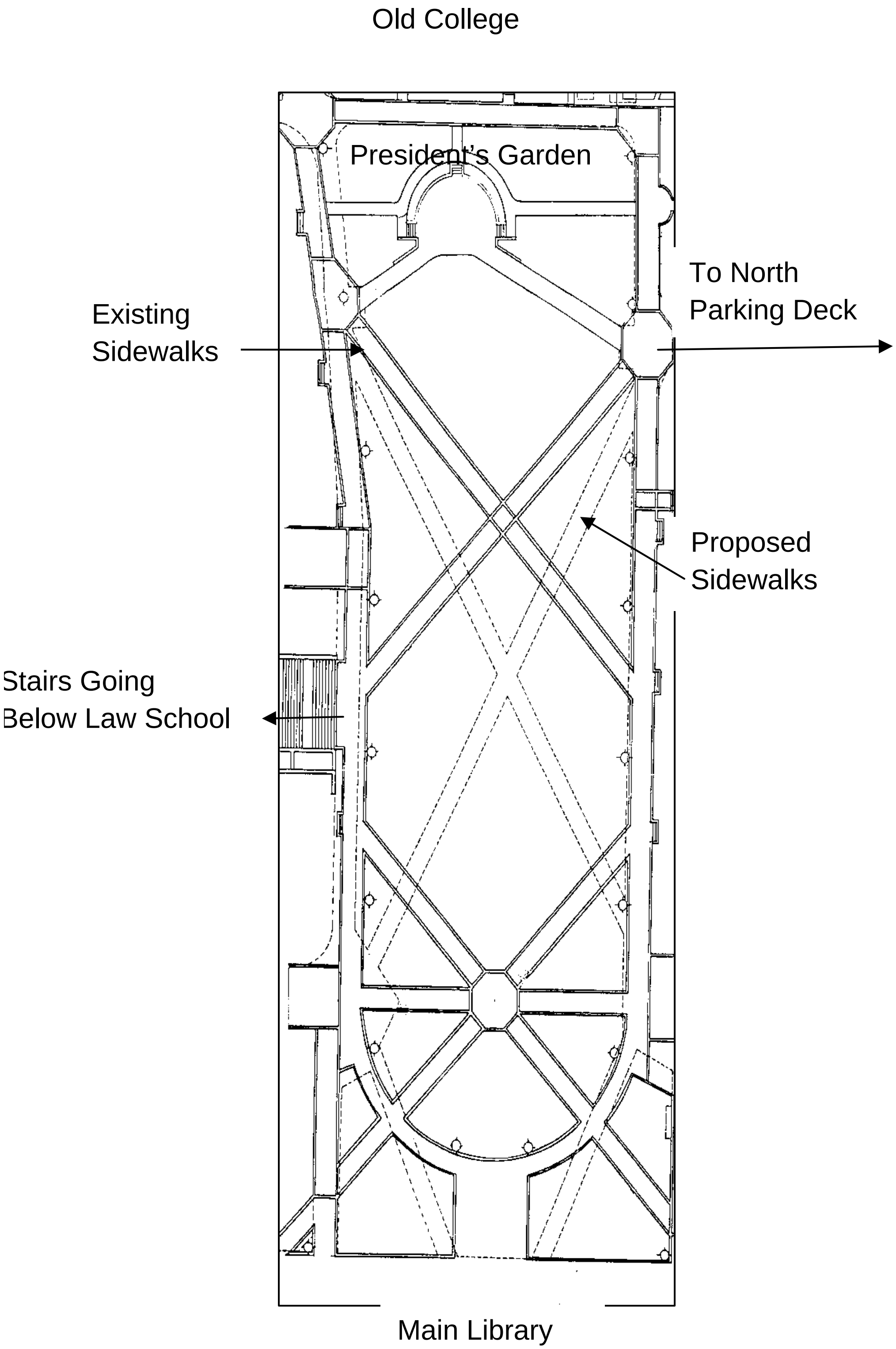
37,000 sf x 12"= 37,000 cf/ 27 (cf in cy)= 1370 cy x $50= **$68,500 ($1.85/sf)**

If that figure is subtracted from the Erth Products figure ($91,650), then UGA will save $23,150. Additionally, If UGA can eliminate the landfill dump fee ($99,900) by finding somewhere on the farm where the compost operation takes place, then it could save **$123,050.** (23,150 + 99,900)

PRICE TO INSTALL THE UGA CU-SOIL/SOD

LABOR	12,000
GENERATOR	2,500
BOBCAT	1,500
SAFETY	500
DIESEL	1,000
12" CU-SOIL	68,500
WASHED SOD	19,795
	$105,795
+ 5% management fee	**$5,290**
SUB TOTAL	**$111,085**
+10% of total figure (Contingency Factor)=	**$11,109**
JOB TOTAL=	**$122,194**
/ 37,000 SF	**$3.30sf**

APPENDIX B: PROPOSED SIDEWALKS FOR THE QUAD



Drawing by Professor Marguerite Koepke with her permission.

APPENDIX C: EVALUATION OF THE SYSTEMS

CU- SOIL

1. forms a locked lattice
2. porosity 40%
3. permeability 6”/hr
4. resists compaction; rutting
5. encourages development of deep rooting
6. load bearing- up to light vehicular traffic
7. can put porous pavement on top
8. hard surface
9. easy installation
10. developed for use with trees
11. trees roots move easily through it
12. washed sod cover
13. restores year-round usefulness
14. streetscapes, islands in parking lots, raingardens, quads, plazas, extra parking areas
15. UGA can become licensee & install its own CU-Soil
16. installed price $3.30/sf (12”)

NETLON ADVANCED TURF

1. forms a 3-D structure
2. porosity 35- 50%
3. permeability 6”/hr
4. resists compaction; rutting
5. encourages development of deep rooting
6. load bearing- up to light vehicular traffic
7. designed for grass on top
8. springyness cushions falls
9. slightly more complicated; special mixer
10. developed for sports fields; extra parking
11. may deflect tree roots; may cause sand shifting
12. washed sod cover
13. restores year-round usefulness
14. extra parking areas, golf greens, fairways, sports fields, helipads, emergency vehicle lane
15. usually contractor installed
16. installed price $3.65/sf (8”)

APPENDIX D: IMPACT ON UGA MAINTENANCE

Existing UGA landscape maintenance:	**$11,200/year**
(includes: lawn maintenance, core aeration, seeding,	
tree work, new tree installations, sprinkler repairs, etc	
for 37,000sf)	
(per conversation with Dexter Adams, campus landscape architect)	
Subtract costs that could be eliminated by CU- Soil & new sod:	**$4,000/year**
Installing the CU-Soil & sod would save UGA:	**36%**
Return on investment would be recouped in:	**3 years**

The above figures were derived from the following computations:

Landscape Maintenance; Mar- Nov (20 visits) @ $300/visit	$6,000
Trees removed & installed (3 visits)	$4,000
Dec- Feb (3 visits) + December graduation	$1,200
	$11,200
$4000/ $11,200 x 100	36%
Amount of maintenance done on UGA campus estimated @ 10x	370,000sf
Savings (10x)	$40,000
Job Total for installing UGA CU-Soil/Sod (Appendix A)	$122,000
$122,000/ $40,000	3 years