# Health Assessment of the Willow Oaks on the Tryon Street Mall Charlotte NC

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**January 18, 2010**

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# Executive Summary

The development of the Tryon Street Mall began in late 1983 using a new strategy called "suspended pavement" aimed at growing large maturing trees in confined areas. This project has been very successful and large trees are now shading the streetscape in Uptown. However, some willow oaks on the Mall have begun to decline in health and die in recent years.

The F.A. Bartlett Tree Expert Company working with the Bartlett Tree Research Laboratories was contracted to: 1) Visually inspect each tree on the Tryon Street Mall to determine its size, location and condition, 2) Select a subsample of the tree population and determine the causes of tree decline, 3) Report on the findings of the study, and 4) Provide recommendations to improve the health and longevity of the remaining willow oak population.

An inventory of the willow oaks on the Tryon Street Mall identified 167 willow oaks ranging from 6 to 27 inches in diameter with an average diameter of 16.25 inches. The condition of the trees was 58% *Good*, 34% *Fair* and 8% *Poor*. Nine trees were found to be lifting the curb or pavement around the tree. Many trees were in contact with buildings, or interfering with street lighting or signage.

A subsample of the inventoried tree population was selected for an in-depth study to determine the causes of the tree decline. The study evaluated many soil and pest related factors that could be associated with tree decline.

The cause of the willow oak decline syndrome on the Tryon Street Mall was identified as the interaction between pests and environmental factors. An infestation by oak lecanium scale on the trees is reducing energy produced in the leaves and Phytophthora root rot is affecting nutrient and water uptake. The environmental factors that are stressing the trees are a lack of water and the associated limitation of soil volume necessary to sustain root and crown growth.

An integrated management program is recommended to improve the health of the trees and extend their effective lifespan. Treatments should include treating the scale insect and root disease, monitoring and managing soil moisture and nutrient levels, and managing tree growth so that the trees can live longer in the limited space available to them.

# Introduction

The City of Charlotte has a long history of growing large maturing trees in residential and business areas. Large trees in all parts of the City are an honorable distinction for the City. Growing large trees in the center city not only enhances the appearance and quality of life in the area, but also provides many environmental benefits.

The *Urban Heat Island* effect is a well documented result of having unshaded buildings and paved surfaces. Large areas of pavement, brick, stone, steel and glass retain more heat in the summer making the environment hotter and unpleasant for pedestrians and those who live in the area. Growing large maturing trees are a primary means of reducing this effect and making the area more pleasant for all who travel and live there.

The development of the Tryon Street Mall began in late 1983. A new strategy was developed at that time aimed at growing large trees while providing for vehicular and pedestrian traffic over their extensive root systems. Previous to this time, only small areas of soil were typically provided for tree root development. The surrounding soil was heavily compacted so as to serve as a solid base for the road, sidewalk and buildings. This compacted soil excluded root development which in turn limited crown growth and tree longevity. In cities where this old strategy is employed, the average tree life expectancy is in the range of 10 to 15 years. With that short life span, trees do not develop to the size where they provide the many benefits of large mature trees.

From a tree perspective, the unique part of the Tryon Street Mall project is that the pavement surrounding the trees does not rest entirely on the soil surface. Rather it is held slightly above the soil by underground walls or pillars. This creates a "Suspended Pavement" and allows the use of a non-compacted, low density soil beneath the pavement. This allows tree roots to grow in a much larger space than most urban trees.

The 193 willow oaks that comprised the Tryon St Mall project were planted in early 1985. The oaks in the 100 block of North Tryon and East and West Trade Streets were 4 to 4 1/2 inches in caliper. All of the rest were 3 to 3 1/2 inches in caliper. Five trees in various locations in the Mall were lost during hurricane Hugo in 1989. The oaks around *Bank of America Corporate Center* and *Blumenthal Performing Arts Center* were replaced with 3 to 3 ½ inch caliper trees when the building was built in the early 1990's.

The Tryon Street Mall planting project has been one of the nation's most successful projects to grow and maintain large trees in the city center. However, there are limitations to tree longevity even in a well planned and maintained project like this one. Over the past few years, a decline in health of many of the trees in this project has been noticed. Some trees have died or are in a serious state of decline.

The F.A. Bartlett Tree Expert Company working with the Bartlett Tree Research Laboratories was contracted to: 1) Visually inspect each tree on the Tryon Street Mall to determine its size, location and condition, 2) Select a subsample of the tree population and determine the causes of tree decline, 3) Report on the findings of the study, and 4) Provide recommendations to improve the health and longevity of the remaining willow oak population.

A risk assessment of each tree was not requested by the City nor was it provided by the Bartlett Tree Expert Company. All trees should be inspected on a regular basis to determine the presence of structural defects and other conditions that could lead to premature tree failure or otherwise impact people and property.

# Materials and Methods

## Inventory of Trees

The Bartlett Inventory Solutions (BIS) team from the F.A. Bartlett Tree Expert Company located each willow oak (*Quercus phellos)* within the defined work area and categorized each tree on certain characteristics. The work area was along both sides of North Tryon Street between 1st and 8th streets, and Trade Street between North Church Street and North College Street.

The BIS team used *Trimble GeoXT* Geographic Position System (GPS) hardware (www.trimble.com/geoxt.shtml), and the integrated Geographic Information System (GIS) software: ArcGIS 9.3 ([www.esri.com](http://www.esri.com)) and ArborVue ([www.arborvue.com](http://www.arborvue.com)) to locate each tree and record tree characteristics.

The following information was collected during the inventory:

1. Tree Location - determined and recorded based on GPS coordinate system
2. Tag Number- a uniquely numbered blue aluminum tags were attached to each tree at a height of about eight feet.
3. Trunk Diameter at a standard height of 4.5 feet above grade (DBH) was measured using a diameter tape *(*www.nycswcd.net/files/Forestry%20Measurements.pdf).
4. Infrastructure Interaction, including sidewalk lifting and building contact was evaluated and recorded.
5. Ground Cover Type- the material on the soil surface was classified as organic mulch, herbaceous plantings or a combination of herbaceous and woody ornamental plantings.
6. Condition Class – tree health was categorized as follows:
    - Dead
    - Poor - Most of the crown exhibiting branch die-back, chlorotic (yellowish) leaf color, and leaf size and twig growth less than typical for this tree species.
    - Fair - Part of the crown had chlorotic leaf color, and leaf size and twig growth was less than typical for this tree species.

- Good - Tree health and condition were acceptable, with predominantly green leaves in the crown, good twig and leaf growth and no significant branch dieback.

## Soil Volume

The soil volume available for root growth has a direct affect the maximum size that a tree can achieve; the smaller the soil volume, the smaller the ultimate size of the tree. The soil volume available for trees in the Tryon Street Mall area is not known for sure. It is estimated from the design drawings to be 12 feet by 19 feet by 3 feet deep or 684 cubic feet.

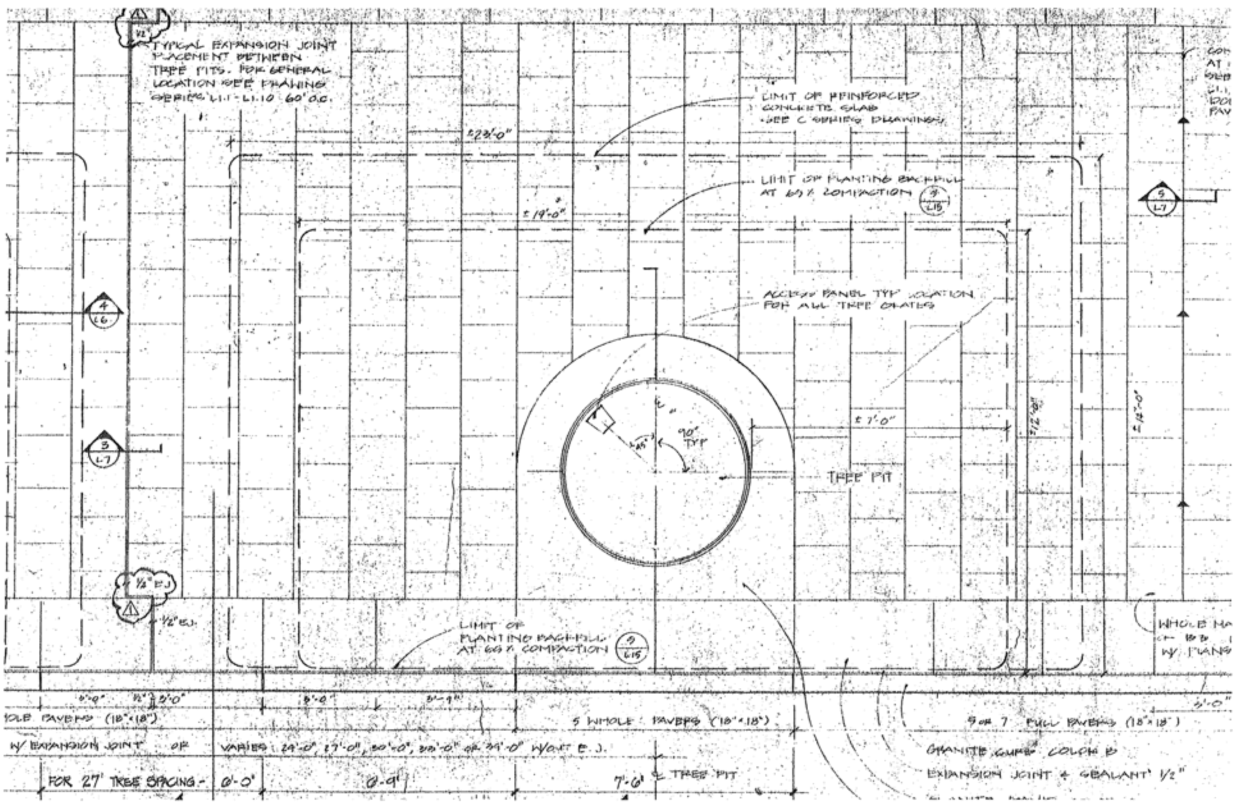


Figure 1. Copy of the Tryon Mall street tree design, top view.

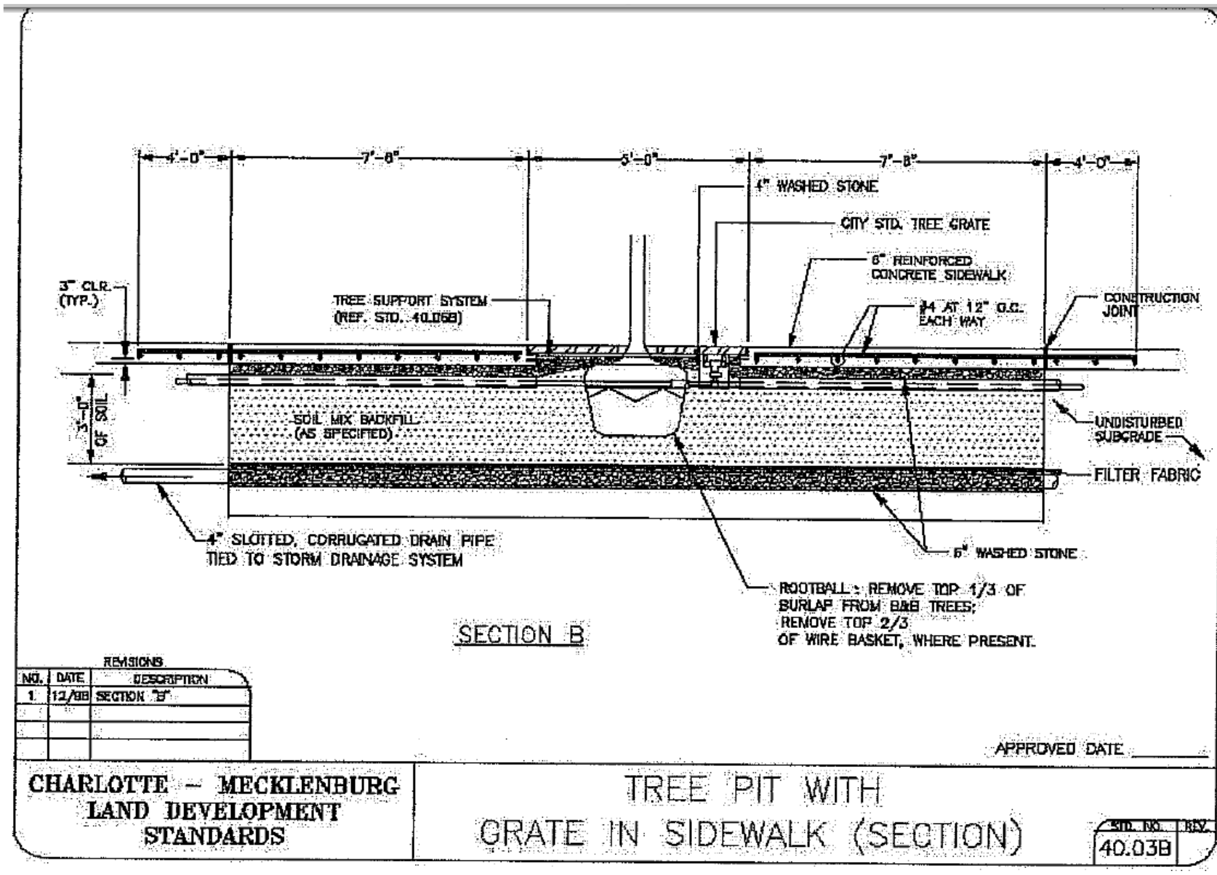


Figure 2. Copy of the Tryon Mall street tree design, side view.

Observations by James Urban and others have been used to develop tables that estimate the maximum trunk diameter and crown size based on the soil volume available (Figure 3). For example, the table shows that to achieve 16 inches in trunk diameter, a tree would require 1000 cubic feet of soil. It should be noted that these growth potential tables were developed for average tree species around the United States that have limited levels of care and may not have irrigation. Tree species and cultural practices can have a profound impact on size. Certain species are more stress tolerant than the average species, and irrigation will allow the growth of larger trees in small spaces. Willow oak is a tree that tolerates small spaces better than most species.

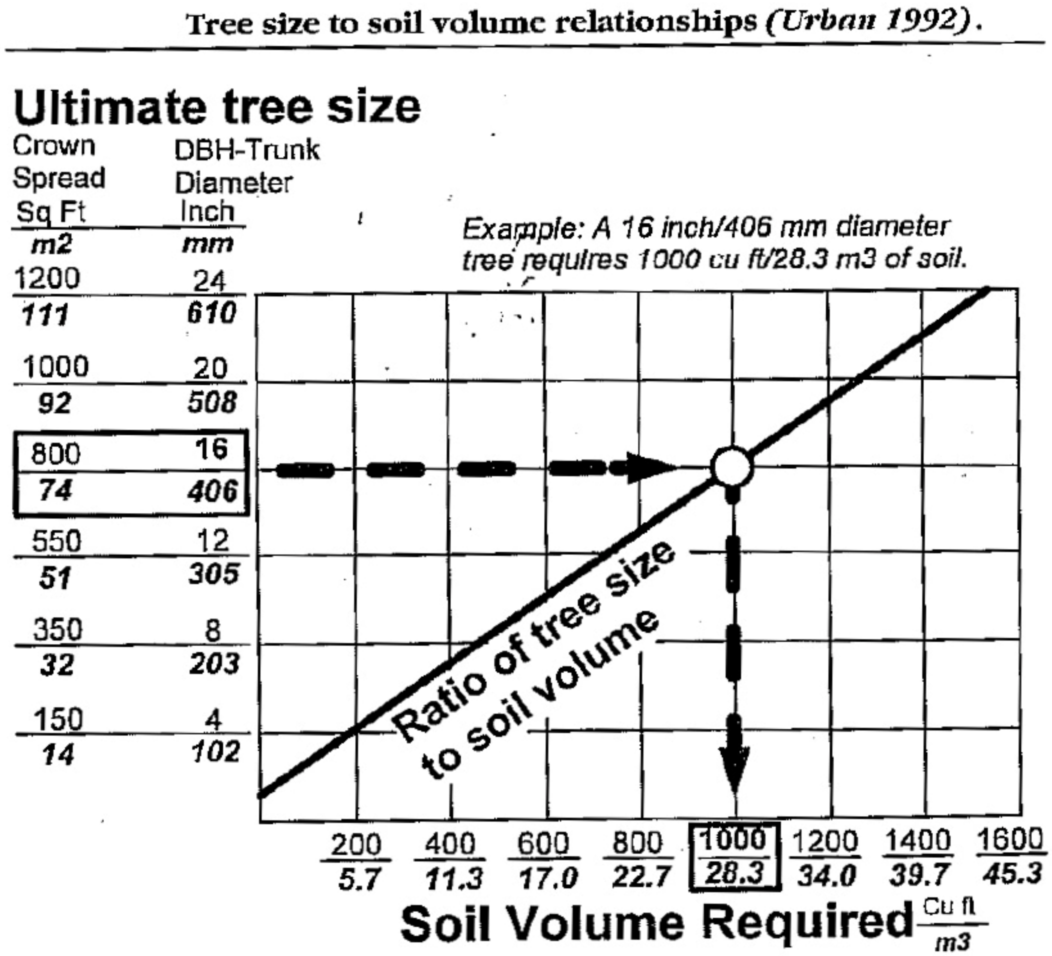


Figure 3. Tree size to soil volume comparison table from James Urban's *Up by Roots*.

### Selection of Trees for In-depth Assessment

After the completion of the inventory, the tree data was stratified based on condition class (*Good, Fair* or *Poor*). Seven trees from each condition class were randomly selected for further investigation. The sample size was set at about 12% of the total tree population. Since more trees were in the *Good* category than *Fair* or *Poor,* the *Fair* and *Poor* trees were represented in higher proportions than the *Good* category trees in the study. The selection process resulted in sampling 7% of the *Good* condition trees, 12% of the *Fair* condition trees and 54% of the *Poor* condition class trees.

## Parameters of the In-depth Assessment

The 21 willow oaks selected for an in-depth assessment were sampled and assessed by several teams which focused on different tree and site characteristics. The assessments were as follows:

1) **Aerial Sampling**

   The aerial sampling team consisted of City of Charlotte, Landscape Management Division staff who operated an aerial lift in conjunction with Matt Story, a Bartlett Arborist Representative, to collect foliage and twig samples from the study trees in September, 2009. Samples were collected from a height of 35 to 50 feet from the street side of the tree. Samples were taken to the Bartlett Tree Research Laboratory, Plant Diagnostic Clinic for evaluation of insect and disease problems on the foliage and twigs. After visual and microscopic examination of the samples by Lorraine Graney and Eric Honeycutt, leaves were sent to A&L Laboratory in Memphis TN for foliar nutrient analysis. Nutrients that were analyzed were: nitrogen, phosphorus, potassium, sulfur, magnesium, calcium, sodium, boron, zinc, manganese, copper, and aluminum.

2) **Ground level assessment**

   The ground level assessment of tree size, condition, ground cover, pavement damage was conducted by Mike Sherwood and Patrick Anderson of the BIS group as previously described in the tree inventory description.

3) **Below grade assessment**

   The soil assessment team consisted of Dr. E. Thomas Smiley, Dr. Kelby Fite, Liza Holmes and George Palmer of the Bartlett Tree Research Laboratories. Assessments were made and the following samples were collected:

   **Soil Profile analysis** – samples were collected using a Dutch Auger (www.ams-samplers.com) at six inch intervals from the soil surface to a depth of 36 inches, unless the soil was impenetrable to this tool. At each interval the soil was assessed for texture, moisture, roots, color, odor and anthropogenic materials. Samples for soil nutrient analysis were collected from the 0-6 inch depth and 12-18 inch depths. Roots were collected from every nutrient sample and tested for Phytophthora root rot using an ELISA test (www.bartlett.com/resources/**Phytophthora**-Diseases.pdf*)*. The soil nutrient analyses included organic matter (OM) content, soil pH, estimated nitrogen release (ENR), phosphorus (P), potassium (K), and micronutrients *(*www.bartlett.com/bartlett-tree-experts-resources-r.cfm?serviceID=8&type=commercialServices).

**Soil Bulk Density analysis** was determined by collecting an undisturbed soil sample using a six inch long Core sampler (www.ams-samplers.com). From the six inch sample, a representative, undisturbed three inch long sample was selected, dried and weighed. Knowing the sample size and weight, the bulk density was calculated (*www.bartlett.com/resources/Soil-Density-Analysis.pdf)*. Samples were collected from depths of 0-6 and 6-12 inches.

**Percolation Testing** was conducted at two different depths, 12 inches and at the greatest depth of the sampled soil profile. Testing was conducted by filling a 2.5 inch diameter hole with water to pre-wet the soil, then refilling the hole with water and measuring the movement of water from the hole into the soil by measuring the decrease in water level (*www.bartlett.com/resources/Soil-Drainage.pdf)*. *Poorly drained* soil are defined as those which perc less than one half inch of water per hour, *moderately well drained* perc less than one inch per hour, *well drained* soils perc one to two inches per hour and *excessively well drained* soils perc more than two inches per hour.

# Results

## Tree Inventory and Ground Level Assessment

The tree inventory identified 167 willow oaks in the Tryon Street Mall study area ranging from 6 to 27 inches in diameter with an average diameter of 16.25 inches. The condition of the trees was *Good* 58% (97 trees), *Fair* 34% (57 trees) and *Poor* 8% (13 trees). Nine trees were found to be lifting the curb or pavement around the tree. The crowns of many trees were interfering with buildings, street lighting or signage. The complete inventory results are presented in a separate report included in the Appendix.

**Street aspect**- the difference in tree condition for those trees growing on the north side of the street was compared with the condition of the trees growing on the south side of the street. It was found that the trees in *Poor* condition were nearly evenly split between the southeast and northwest side of the street.

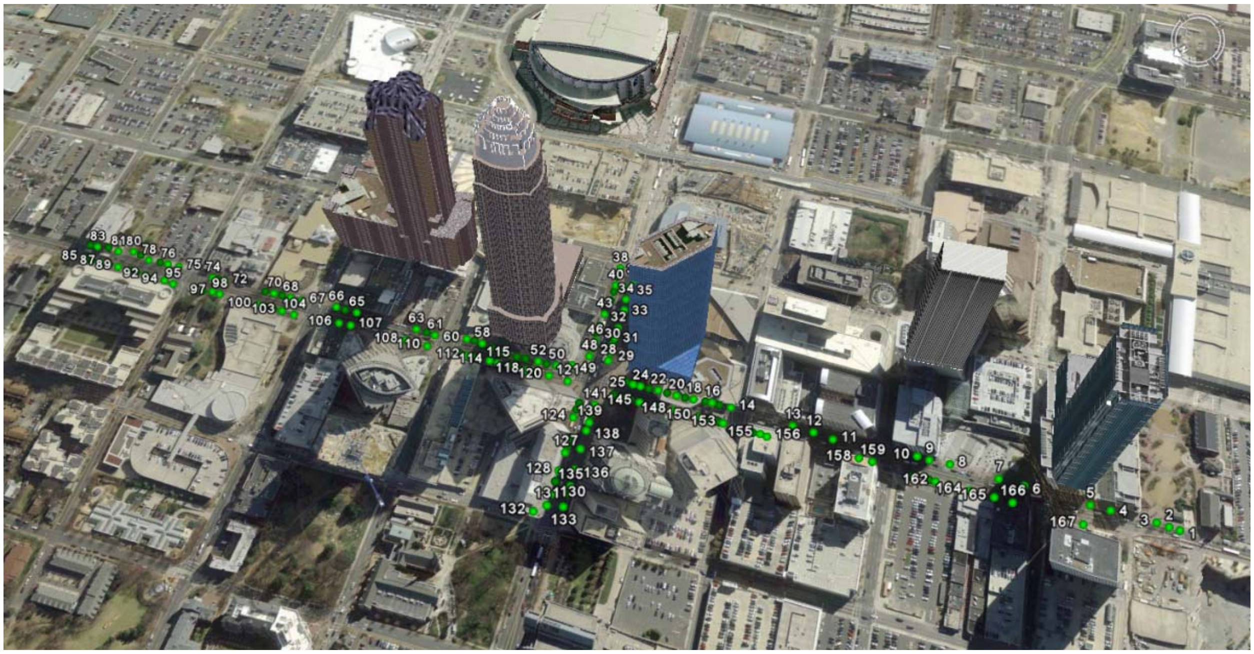


Figure 4. Tree inventory location results overlaid on Google Map view of Uptown Charlotte.

The results of the ground cover survey are presented in Table 1. There were no significant correlations between ground cover type and tree health condition.

Table 1. Number of willow oak planting sites with various Ground Covers.

| | Number of trees in In-Depth Study | | | Number of trees in Complete Inventory | | |
|---|---|---|---|---|---|---|
| Condition Class | Mulch | Herbaceous plants | Woody and Herbaceous | Mulch | Herbaceous plants | Woody and Herbaceous |
| Poor | 4 | 3 | 0 | 8 (66%) | 4 (33%) | 0 |
| Fair | 5 | 2 | 0 | 39 (67%) | 19 (33%) | 1 (2%) |
| Good | 5 | 1 | 1 | 64 (67%) | 29 (30%) | 2 (2%) |

For the trees that were included in the subsample, the mean diameter was 14.7 inches. Trees in the *Poor* health classification averaged 13.1”, *Fair* 15.7” and *Good* 15.3”.

## Aerial Sampling Results

**Foliar Insect and Disease Assessment** – Two different foliar diseases were found on the samples, an unidentified fungal leafspot and powdery mildew. These diseases are considered non-life threatening. Both of these diseases were only found on trees identified as being in *Poor* condition.

One insect was found on the foliar samples, the oak lecanium scale (*Parthenolecanium quercifex*, http://www.ces.ncsu.edu/depts/ent/notes/O&T/trees/note36/note36.html). The density of the scale crawlers (the immature stage found on leaves) was rated on a scale of one to three, with one being low and three being high density (see Appendix). There was a strong correlation between the number of crawlers and the condition of the trees. Trees in *Good* condition had a mean scale density rating of 1.7, *Fair* 2.1 and *Poor* 2.3. This scale insect is known to impact the health of oak trees and is considered a life-threatening pest.

**Foliar nutrient analysis** – One nutrient, phosphorus, was found to be at less than optimum levels in the foliage. None of the nutrient concentrations were correlated to the condition of the trees. That is, the healthier trees (*Good* condition) did not have significantly higher or lower levels of any nutrients as compared with the *Poor* condition trees. High levels of aluminum were found in all trees. This element often indicates fine root damage or disease. Mean levels of all tested nutrient for the different condition classes are presented in Table 2.

Table 2. The mean **Foliar Nutrient levels** and tree condition class ratings for 21 Tryon Street Mall willow oaks included in the subsample.

| Element tested | Mean level in trees in **Poor condition** | Mean level in trees in **Fair condition** | Mean level in trees in **Good condition** |
|---|---|---|---|
| Nitrogen % | 2.6 sufficient | 2.6 sufficient | 2.3 sufficient |
| Phosphorus % | 0.15 low | 0.15 low | 0.15 low |
| Potassium % | 0.77 sufficient | 0.83 sufficient | 0.85 sufficient |
| Sulfur % | 0.19 sufficient | 0.19 sufficient | 0.19 sufficient |
| Magnesium % | 2.9 sufficient | 2.9 sufficient | 3.0 sufficient |
| Calcium % | 1.1 high | 1.1 high | 0.9 high |
| Sodium % | 0.02 acceptable | 0.02 acceptable | 0.02 acceptable |
| Boron ppm | 52 high | 65 high | 57 high |
| Zinc ppm | 70 high | 71 high | 71 high |
| Manganese ppm | 2118 very high | 2089 very high | 2728 very high |
| Iron ppm | 470 high | 594 high | 435 high |
| Copper ppm | 16 high | 17 high | 15 high |
| Aluminum ppm | 260 high | 303 high | 238 high |

## Below Grade Assessment

**Soil depth** did not exceed 36 inches in any of the tree pits tested. An impenetrable layer or layer of gravel was encountered at or before 36 inches; the soil was impenetrable by 24 inches for most trees. The mean depth to the impenetrable layer was not significantly different among the condition classes. The mean depths were *Poor* 27 inches, *Fair* 28 inches, *Good* 26 inches.

**Soil Texture** soil texture varied from site to site and with soil depth (Table 3). There were no significant differences among trees of different condition classes.

**Soil Moisture** levels in the critical upper six inches of the soil profile were dryer in the *Poor* condition trees than the *Good* condition trees (Table 3). *Poor* and *Fair* condition trees tended to be wetter in the lower sections of the soil profile than the *Good* condition trees. None of the soils were classified as anaerobic or gleyed, meaning that none of the soils had recently been wet for more than a few weeks.

Table 3. Typical **soil texture** and **moisture** at different depths. Asterisk (*) indicates significant difference between *Poor* and *Good* condition trees.

| | Predominant **Soil Texture** for willow oaks in these condition class: | | | Number of trees with each **Soil Moisture** class for willow oaks in these condition classes: | | |
|---|---|---|---|---|---|---|
| Soil Depth in inches | **Poor** | **Fair** | **Good** | **Poor** | **Fair** | **Good** |
| 0-6 | Clay loam | Clay loam | Clay loam | 5-dry*<br>2-moist | 2-dry<br>5-moist | 2-dry<br>5-moist |
| 6-12 | Clay loam | Clay loam | Clay loam | 2-dry<br>4-moist<br>1-wet | 2-dry<br>4-moist<br>1-wet | 1-dry<br>6-moist<br>0-wet |
| 12-18 | Sandy or Gravely Clay loam | Clay loam | Sandy Clay loam | 2-dry<br>4-moist<br>1-wet | 2-dry<br>3-moist<br>2-wet | 2-dry<br>5-moist<br>0-wet |
| 18-24 | Gravel or Sandy clay loam | Gravel or sandy clay loam | Gravel or sandy loam | 2-moist<br>1-wet<br>4-impenetra | 1-moist<br>2-wet<br>4-impenetra | 0-dry or wet<br>3-moist<br>4-impenetra |
| 24-30 | Impenetrable or sandy loam | Impenetrable or sandy loam | Impenetrable or sandy loam | 1-moist<br>1-wet<br>5-impenetra | 0-dry, moist<br>2-wet<br>5-impenetra | 0-dry, wet<br>1-moist<br>6-impenetra |
| 30-36 | Impenetrable | Impenetrable | Impenetrable | Impenetrable | Impenetrable | Impenetrable |

**Root Rot Assessment –** Phytophthora root rot is a disease that affects a large range of trees, shrubs and herbaceous plants (http://www.bartlett.com/insect-and-disease-management.cfm?rs). Phytophthora is a soil pathogen that kills fine roots necessary for water and nutrient uptake. The pathogen can progress into the root collar and lower stem of the tree under certain circumstances.

Poor soil drainage and excessively wet soils are known predisposing factors to Phytophthora root rot. This disease was positively identified in 15 of the 20 root samples collected. All condition classes were equally infected with this disease.

**Soil Nutrient Analysis** –Nutrients in the upper six inches of soil are most important for tree growth. Soil analysis revealed suboptimal levels of potassium, magnesium, calcium, and manganese in most of the study trees (Table 4). Low levels of sodium and salinity were also identified; this is beneficial for willow oak. Nutrients that had significantly different levels between the trees in *Good* and *Poor* condition were phosphorus and manganese. Soil pH values were slightly higher in the *Poor* condition trees than the *Good* condition trees. Both pH values were within the optimum range for willow oak.

Table 4. **Soil nutrient analysis results** from samples collected at different depths and sorted by the condition class of the willow oak trees. Asterisk (*) indicates a significant difference between *Poor* and *Good* condition trees.

| Nutrient or factor analyzed | Results from Soil Sample collected from **0-6 inches** | | | Results from Soil Samples collected from **12-18 inches** | | |
|---|---|---|---|---|---|---|
| | **Poor** | **Fair** | **Good** | **Poor** | **Fair** | **Good** |
| Soil pH | 5.7 | 5.6 | 5.1 | 6.6 | 6.4 | 6.4 |
| Soil Organic Matter % | 5.0 high | 5.0 high | 4.8 high | 3.9 med | 4.2 high | 3.4 med |
| Nitrogen (ENR) ppm | 124 high | 125 high | 121 high | 101 med | 109 high | 92 med |
| Phosphorus ppm | 243v hi * | 87 high | 103 high | 180 v hi | 82 high | 176 high |
| Potassium ppm | 322 high | 262 med | 254 med | 284 med | 287 med | 252 med |
| Magnesium ppm | 258 med | 267 med | 245 med | 261 med | 278 med | 246 med |
| Calcium ppm | 3165 med | 2226 med | 1895 low | 4450 high | 3710 med | 4227 med |
| Sodium ppm | 135 low | 75 v low | 67 v low | 99 v low | 72 v low | 70 v low |
| Soil Salinity | 0.21 v low | 0.14 v low | 0.17 v low | 0.14 v low | 0.14 v low | 0.15 v low |
| Iron ppm | 629 v hi | 598 v hi | 638 v hi | 543 v hi | 677 v hi | 618 v hi |
| Manganese ppm | 136 low* | 92 v low | 63 v low | 138 low | 125 low | 97 v low |
| Copper ppm | 13 high | 8 high | 8 high | 8 high | 8 high | 10 high |
| Zinc ppm | 80 v high | 28 v high | 28 v high | 85 v high | 18 high | 22 high |
| Boron ppm | 1.1 high | 1.0 med | 0.9 med | 1.1 high | 1.2 high | 1.1 high |

**Anthropogenic Materials** were consistently found in the tree planting area. The main material found was a nonwoven geotextile commonly used as a filter fabric or weed barrier. This horizontal layer was typically found at a depth of six inches, so it was not located correctly for either of these uses. The horizontal extent of this material was not determined. When intact, this fabric is impenetrable to tree root growth.

# Conclusions

The cause of the willow oak decline syndrome on the Tryon Street Mall was identified as the interaction between pests and environmental factors. This is a classic case of a tree "Decline Syndrome" where there is an interaction of multiple factor that combine to reduce the vitality of the trees. The infestation by oak lecanium scale is reducing the availability of energy produced in the leaves and Phytophthora root rot is affecting nutrient and water uptake. The environmental factors that are stressing the trees are a lack of water at certain times and the associated factor that the trees have grown beyond the soil volume necessary to sustain root and crown growth.

While the design specifications for the soil area called for 684 cubic feet, it was found that because soil depth in a majority of sites was closer two feet than three, that the actual soil volume was closer to 456 cubic feet in many sites (assuming a 12 by 19 foot horizontal space). There is also the possibility that the geotextile found six inches below grade limits rooting volume even more. Either way, the current mean tree trunk diameter of 16 inches exceeds the predicted maximum trunk diameter for the soil volume of these sites as shown in Figure 3.

The dry conditions found in the topsoil of most of the sites with trees in *Poor* condition indicate that the soil was not receiving sufficient irrigation prior to the study. It is likely that the droughts of 2005 through 2007 also played a major part in the initiation of the decline syndrome.

The lack of evidence of saturated soil indicates that the drainage system installed below all trees is still functional. This is beneficial for the trees and will allow some increase in irrigation when a drought is encountered. Phytophthora root rot is most damaging when soils alternate between dry and saturated.

# Recommendations

To improve the health of the trees in the Tryon Street Mall an integrated tree management approach is recommended. Since not all of the factors involved in this decline syndrome can be corrected, those factors which are practical to treat should be treated. Treatments that should be made consists of monitoring and treating insects and diseases, managing soil moisture and nutrient levels, managing tree growth, and treating other soil problems. Details are as follows:

All scale infested trees should be treated with the soil applied insecticide imidacloprid in the winter of 2010 or dinotefuran in late winter 2010 to manage the scale population. The scale population should be monitored in the summer of 2010 to determine if additional treatments will be needed and to determine the level of mite activity. If imidacloprid is applied at the medium rate, retreatment should not be needed until 2012 or 2013.

Treat all trees for Phytophthora root rot with soil applications of a phosphite fungicide (eg. Agri-fos) alternating with mefenoxam fungicide. Three soil applications should be made the in 2010 starting in March with mefenoxam followed by applications in June with phosphite and September with mefenoxam. The disease level should be reevaluated in the late fall 2010 to determine if more than one application will be required in 2011.

The irrigation system should be inspected on all trees to ensure that it is functioning. Irrigation should be applied after pest treatments are made if there is not adequate rainfall to evenly distribute the material. During drought periods, water should be applied based on soil moisture levels. Soil moisture levels should be monitored electronically using *Watermark*™ (http://www.irrometer.com/sensors.html#wm) or similar sensors, or manually by examining soil cores during the entire growing season. Monitoring should include soil at a six inch depth to assess plant available water and at an 18 inch deep to assess drainage conditions.

Since the trees greater than 12 inches in trunk diameter are likely to have exceeded the maximum soil area, these trees should be managed to slow their growth. By managing the crown growth rate, the trees should have a longer life expectancy. There are two basic methods of managing growth under the conditions found on the Tryon Street Mall - pruning and growth regulators.

Pruning can be used to reduce or maintain the crown size of the trees. By limiting the crown size or density, tree growth will be slowed. If pruning is done it should be Thinning (as described in the ANSI A-300 standard) of the outer crown. To ensure the desired effect from pruning, at least one tree pruned should be pruned under the direct supervision of the City Arborist or the staff of the Bartlett Tree Research Laboratory who are familiar with the pruning standards. This will serve as a standard for pruning crews or contractors.

The second option for managing tree growth is the use of a tree growth regulator (TGR). Paclobutrazol is commonly available, soil applied TGR used for trees. It reduces new growth rates for about three years. A combination of pruning and growth regulation can also be used.

Neither of these growth management treatments should be done until the scale and root rot problems have been managed. This will allow the crown to increase in density before growth is limited. Initiating growth management too soon can lead to an undesirable appearance in the tree crown and may increase tree stress levels.

Soil nutrient levels should be monitored and trees fertilized on a prescription basis. At the current time, fertilization with potassium, magnesium and manganese is recommended. This treatment should be made during the winter of 2009-2010. Soil phosphorus and foliar nitrogen levels do not justify application of these nutrients at this time.

The practice of mulching with an organic material such as wood chips, should be continued as needed to improve soil and tree health. Mulch should not be installed against the trunk.

When trees do die and need to be replaced, the irrigation and water drainage systems should be inspected and checked for functionality. If the drain system is damaged and becomes non-functional, success of newly planted trees will be limited due to the accumulation of water in lower level of the soil.

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