The Policy and Practice of Tree Conservation During Infill Development

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Part 1: Introduction

About This Manual

Communities across the state of North Carolina are being impacted by a sprawling pattern of growth that is not fully sustainable due to increasing infrastructure cost, environmental impacts, loss of open space, forestland, and farmland, and lengthy commutes. At the same time, there is a renewed interest in town living, for shorter commutes, more walk-able lifestyles, and greater access to dining, entertainment and social/cultural opportunities. This has led to a dramatic increase in infill development: the development of vacant or underused land within in existing urban areas that are largely developed.

Examples of Infill Development

Infill development can take many forms. The following are common examples of changing land use patterns, which could be described as infill development.

- Building on land that was once formerly considered unsuitable for development due to existing constraints such as topography. As demand and land values increase, it becomes more cost effective to address these constraints.
- Building on land whose value has increased to where it can support a higher use, such as the conversion of apartments to a residential, commercial mid-rise; or the conversion of commercial strips to townhomes or apartments.
- Renewal of housing, such as the demolition of older homes to build a newer and larger home. Today's homeowners prefer higher square footage, multiple bathrooms, and larger closets.
- Subdivision of a large, single-family lot into multiple lots for home construction.
- Remodeling an existing home to add and additional space.

From an urban forestry perspective, infill development is particularly challenging because the trend toward building large structures on small lots often occurs around old and maturing trees with expansive root systems. Trees are either removed outright to accommodate the new structures, or trees end up declining and dying as a result of construction damages. Declining trees often become a risk due to dead limbs or entire tree failure due to cut roots. It is also common for trees on neighboring lots to be damaged by construction activities. ***Land development and building construction is a very complicated process often guided by inflexible local standards and regulations, while trees are complicated and stationary biological organisms.*** In the clash of these realities, the trees typically suffer a catastrophic loss of the requirements needed to survive and, consequently, humans derive fewer benefits from the trees.

The purpose of this manual is to provide information to improve the practice of tree protection, and to inform the creation of local public policy which encourages tree protection and increases the chances of trees surviving infill development. This publication can be used in several ways:

- to provide community members with the tools to influence local tree ordinances that can optimize tree protection,
- to provide a layperson with an understanding of the subject from an urban forest practitioner's perspective, and thereby better enable tree protection in their neighborhoods, and
- to provide the necessary tools to protect trees during a construction project.

The manual will first build your understanding of the importance of trees and their requirements for survival as well as your understanding of the building and construction process – as that process relates to the survival of trees.

Part two of the manual introduces the potential role of tree ordinance in protecting trees during infill development. The sections that follow are typical steps that would be involved in tree ordinance implementation.

Understanding both the limitations of trees along with the potential for local regulation, sets the stage for thinking ahead about tree survival needs, or planning to save trees in the site design process. Specific elements for tree protection are discussed as part of this plan, as well as special considerations for trees that are off site but still potentially impacted by construction (boundary trees).

Implementation of the plan follows as the construction process begins, and this section presents ideas on ensuring that the plan is followed, ways to gently encroach on the trees and their "save areas" (the are designated for protecting the tree and their roots) when plans change, and some cautions for last minute mistakes as building projects near completion.

The last section of the manual addresses post construction considerations, including treatments to improve and maintain trees' condition and health, routine maintenance recommendations, and some tips on managing trees. Applications to local tree ordinances will be interjected where appropriate, throughout the manual

The Importance of Trees

Our urban trees are very hard working trees. They work hard to survive in an often-harsh urban environment and they work hard to provide us many benefits that, in turn, help us survive. There is an ever-growing body of literature and tools that describe and quantify these benefits, which are usually broken down into three broad categories of services: environmental, social, and economic.

- *Environmental services* (sometimes referred to as ecosystem services) range from moderation of local (micro) climate to global significance, and have a positive effect on the air you breath and the water you drink.
- *Social benefits* include the healing power of trees, their calming effect, and their ability to increase public safety.

- *Economic benefits* range from lower utility costs from reduced air conditioning use; to increased real estate values and increased foot traffic in commercial districts.

The following list provides greater details on the full range of benefits. This information was derived from a variety of sources (see Additional Resources). It is important to become familiar with this list because it underscores the importance of tree conservation, protection, management, and replacement.

The Benefits of Trees

Environmental Benefits

- Trees store carbon, one of the major greenhouse gases, in their trunks, branches and roots.
- Urban tree canopy reduces the urban heat island effect, resulting in a reduction of fossil fuels consumption for cooling.
- Reducing the urban heat island leads to a decrease in smog formation.
- Trees help intercept particulate air pollutants.
- Urban tree canopy reduces the rate of storm water runoff, increases water infiltration into the soil, reduces soil erosion, and improves water quality.
- Wildlife habitat

Social Benefits

- Aesthetic; trees, define a sense of place, screen harsh scenery, provide space definition and landscape continuity.
- Reduces stress.
- Traffic calming.
- Decreases respiratory disease, skin cancer and generally improves human health.
- Reduces attention deficit.
- Crime reduction.

Economic Benefits

- Reduced air conditioning costs.
- Increased home real estate values.
- Shoppers linger in shady, landscaped commercial districts.
- Increased commercial occupancy

The dramatic shade pattern on this roof demonstrates a multitude of benefits provided by trees. The shade and the evaporative cooling from the leaves keep the house cooler so less air conditioning is used, saving the homeowner money. Additionally, reducing electricity consumption results in less production of atmospheric carbon and less air pollution.

How Trees Work

Just like all other living things, tree biology is based on systems and their processes, which provide for basic needs such as growth, nutrition, and natural defenses. While it is not necessary to know all of the intricate details of tree biology, a basic understanding provides insight when considering the impacts of a changing environment brought on by construction.

A tree needs all of its parts in good working order, as all of its parts and processes are linked and dependent upon one another for tree survival. A breakdown in, or damage to, any of these systems causes the tree to reallocate resources (like nutrients, water and sugars) that it needs elsewhere. This can make trees more vulnerable to insect or disease, face an increase likelihood of tree failure or dying branches and roots, and ultimately enter into a spiral of decline.

The following table associates basic tree parts with their biological function.

Table 1: The Parts of a Tree

Part	Purpose
Roots	• Anchorage • Root elongation • Storage of food reserves • Respiration • Uptake and transport water, mineral nutrients, photosynthates. • Defense.
Trunk and Branches	• Support • Storage of carbohydrates • Transport of water, mineral nutrients, photosynthates. • Defense
Leaves	• Respiration • Transpiration • Photosynthesis (food and energy)
Flowers, Shoots, and Buds	• Reproduction • Branch elongation

ROOTS

Tree roots occupy a space called the soil environment. Roots occur in this space ***from the soil surface to about 3 feet deep (with a majority of tree roots in the top 6 to 18 inches), and can easily extend out as far as the tree is tall, and beyond***. This means a tree 90 feet tall could have roots extending out at least 90 feet from the trunk.

The survival of a tree is highly dependent on the conditions of the soil environment. It must have the appropriate balance of mineral nutrients, water, organic matter, soil pore space (available oxygen), and other organic life.

As Table 1 indicates, roots play a critical role in a tree's survival. They provide anchorage and support for the tree, and take up water and mineral nutrients that are integral to many of the other biological processes, which occur in other parts of the tree.

Tree roots typically occur in the topmost 3 feet of soil.

TRUNK

The tree trunk and the branches are made up of a series of layers starting with the outer bark, which helps the tree maintain moisture, insulates against temperature extremes, and helps prevent attacks from insects and disease.

Inside the bark is a thin layer called the inner bark or *phloem*, which transports nutrients to the rest of the tree. Inside the phloem is the part of the trunk that is actively growing. This is called the cambium. The cambium produces phloem to its outside and wood to the inside.

The wood makes up the final two layers deeper inside the tree, sapwood, and heartwood. Sapwood transports water and soil nutrients to the rest of the tree. As new sapwood is produced the older sapwood begins to lose its vitality and becomes heartwood. Heartwood provides strength and support to the tree. The strength of heartwood remains almost indefinitely, as long as the other layers remain intact.

LEAVES, SHOOTS & BUDS

The primary role of leaves is to absorb sunlight for the manufacture of sugars (food) by photosynthesis. During this process carbon dioxide is absorbed and oxygen is released

Shoots and buds provide elongation, growth and the production of flowers (reproduction). The buds, along with root tips, are also centers for the production of hormones which control the behavior of cell growth and development in trees, such as cell division, shoot elongation, wood strengthening, flower production, root development and leaf fall.

One of the most important processes occurs in the leaves and green tissues of the tree: photosynthesis, where sunlight is captured in the leaves and converts water and carbon dioxide into oxygen and carbohydrates. The other significant process occurs in all cells within a tree: respiration, where oxygen is broken down into carbohydrates to release energy, creating water, and carbon dioxide.

Additional information on basic tree anatomy is provided in the reference section.

Spiral of Decline

A typical cause of tree damage during construction occurs when tree roots are cut, removed, or covered with fill material. The tree may not die immediately, but will typically begin a slow decline process. Firstly, the tree now has a reduced ability to take up and transport water and mineral nutrients. As a result, the crown begins to die back, which results in fewer leaves for photosynthesis. A reduction in photosynthesis means less sugars and food is produced to send to the roots and the rest of the tree, and less is available for storage for necessary spring growth. This further affects the ability of the roots to grow new roots, and also makes the tree more vulnerable to insects and disease, which cause even more stress to the food production and transportation processes. At this point the decline accelerates until the tree is dead.

How Construction Impacts Trees

There are two basic ways that trees are impacted by construction activity:

- Physical damage (to the roots, trunk or branches), reducing the ability to carry out the necessary biological functions, or
- Altered growing environment (including the soil), changing the availability of, or access to, nutrients, water and soil oxygen.

Excavation results in cut roots, which reduces the rooting area of the tree and its ability to both physically support the tree and to provide nutrients and water to the rest of the tree.

Heavy equipment can cause mechanical damage to the trunk and bark, which disrupts the vascular system of the tree, destroys its defenses against decay, and requires essential energy to seal over the wounds.

Fill material disrupts root respiration and causes root dieback, which typically results in slow tree decline and subsequent decay. This decline can take up to seven years after construction to be fully apparent.

Multiple impacts result in more rapid decline and death: compacted soil from equipment traffic and cut roots from construction of the wall footing.

Typical signs of construction damaged trees Include thinning and yellowing crowns and an increase in dead branches.

Table 2: Construction Activities and their Potential Impacts to Trees

Activity	Impacts
Grade Changes (reducing the grade)	Cut roots, decay, potential wind throw, and disruption of the natural soil environment.
Grade Changes (building the grade)	Fill material over the root system can interrupt the natural exchange of oxygen and carbon dioxide in the soil environment, disturbing the trees biological process. Soil compaction produces the same effect, and could also result in physical damage to the roots.
Disruption of natural drainage patterns	Decrease in available water, or an increase in water. Standing water creates anaerobic soil condition, which disrupts root respiration.
Trenching for utilities (sewage, gas, water, cable, electric)	Cut roots.
Excavation for footings and foundations	Cut roots, soil compaction, and disruption of the natural soil environment.
Mechanical damage to trunk and branches.	Decay, loss of structural integrity, disruption of biological processes.
Tree removal, clearing	Trees roots tend to tangle and fuse. Tree removal with heavy equipment could tear and shred root of adjacent trees. Clearing could expose adjacent trees to sunscald and wind throw. Disruption of the natural soil environment, and soil compaction
Storage (construction materials, equipment, construction debris))	Soil compaction, and potential toxic spills.
Spills (paints, concrete washout, fuels)	Direct contact with fuels has a disintegrating effect on root cell membrane. The digestion of fuels by soil microorganism can result in the depletion of soil oxygen. Concrete washout can alter the soil pH
Debris disposal (burning or burial)	Compacted soil, potential scorching of tree parts, and the loss of soil microorganisms.
Improper pruning for clearance over new structures	Decay and potential structural imbalance.

Part 2: Infill Development and Tree Ordinances

Many communities that are under heavy development pressure choose to develop local public policy to optimize tree protection. (See the publication Developing Tree Protection Ordinances in North Carolina – A Tree Protection Ordinance Tool). The unique nature of infill development (specifically the conflict between mature trees and the tendency to put larger or higher density structures on smaller lots) requires special considerations. In order for an infill development focused ordinance to be effective, the following key factors that should be considered:

1. A community-wide "no net tree or canopy loss" policy should be established, along with minimum tree coverage standards (on a per lot or per acreage basis, *regardless of pre-existing site conditions*). This is particularly important with large-scale infill development projects where the presence of existing trees might be limited. For example, if an old car dealership or commercial strip without any trees is being converted into midrise residential-retail space, minimum coverage standards will bring trees back into that acreage.

2. It is further recommended to require the protection of some established minimum number of or percentage of existing trees on a per parcel basis. This will require builders to place serious consideration towards site planning and organization, and result in tree replacement if trees are removed (see Part 2: Planning for Tree Protection).

3. Tree protection ordinances should NOT be thought of as growth management tools. Tree protection ordinances are not intended to stop growth, building construction or infill development, but are intended to optimize tree protection and replacement.

4. Take full advantage of other existing policies that might also help facilitate tree protection. For example, a variance to required building setbacks (required by zoning code) could provide more space for tree roots. (See the text box below).

5. Build flexibility into your ordinance, and allow for creativity. Having the ability to compromise, make administrative decisions, and allowing alternative compliance will strengthen your ability to reconcile conflicts between building construction and the biological limitations of trees.

6. Establish strong channels of communication between the various staffs involved in permitting and inspections. Storm water management, utilities, traffic planning, and planning and zoning staff may all have interests that may conflict with tree protection planning.

7. Commit to professional staffing for implementation and enforcement of the tree ordinance. It is critically important to have an experienced arborist on staff who understands tree biology and building construction, to promote the ordinance, review tree protection plans for compliance, provide instruction and advice to design professionals and builders, negotiate with other staff interests, ensure accurate implementation in the field, and provide enforcement.

Rezoning and Variances

As infill development occurs, it may become necessary to change a community's zoning maps to allow for a higher density land use. For example, a change to more housing units per acre, or the conversion of single family residential to mixed-use (retail and multi-family residential), would require rezoning. **Rezoning** is a process that starts with an application submitted by the petitioner or property owner, followed by a staff review process that includes input from potentially impacted neighbors, planning commission review, and finally, a decision by city council. The approval of rezoning requests is often accompanied with conditions (conditional approval), allowing the changes in land use only if those conditions are met. Conditional zoning approval is important for communities to get developers to provide infrastructure that may be necessary to support their projects, such as turn lanes, sewer and drainage improvement, traffic signals, etc. Conditions can also be used to require vegetative buffers, and to require developer compliance to the community's tree protection and replacement standards.

It should be noted that in North Carolina it is illegal to impose conditions on rezoning to *conventional* zoning districts. However, this can be done if either conditional use district rezoning or conditional zoning is used. There are, however, detailed legal requirements that must be followed if either of these two zoning tools are used.

A **variance** is a deviation from the set of rules a municipality applies to land use and land development; typically a zoning ordinance, building code or municipal code. Variances can be a useful tree protection tool in terms of allowing a builder some flexibility in site design, with lot setback requirements or height restrictions. For example, a builder might seek a variance to exceed maximum height standards to reduce the horizontal footprint of a proposed structure, allowing for more undisturbed rooting space.

Sample Tree Ordinance Addressing In Fill Development

One of the more successful tree ordinances, addressing in-fill development in the Southern US is the tree ordinance for Decatur, GA. Decatur is a small city (4 square miles) with a very high population density (nearly 5000 residents per square mile), located next to Atlanta's east side and inside the Atlanta perimeter highway. The "live work play", and walkability nature of Decatur, combined with its proximity to downtown Atlanta, regional transit, public and private universities, and good public school system, makes it a highly desirable place to live. As a result, the city's neighborhoods are experiencing a tremendous renewal of their housing inventory and commercial districts are moving towards higher density and mixed uses. The neighborhoods also have a maturing population of trees typical of the area; oaks, hickories, poplars, and pine. Combining the desire for homes with larger footprints on small lots, with maturing tree populations sets the stage for conflict that will result in the construction damage and loss of tree (and tree canopy) and the loss of neighborhood character. As a result Decatur adopted their Tree Canopy Conservation Ordinance. Highlights of this ordinance listed in the text box below.

Highlights of the Decatur Tree Canopy Conservation Ordinance

- Requires permitting for and tree removal, across all ownerships and land uses, including tree removals for building construction and land development.
- Establishes a "no net loss" canopy policy, requiring the replacement of any canopy removed. (An exemption is provided for trees that present a risk for failure, and for dead or dying trees).
- Requires the development of tree conservation plans prepared by a certified arborist, for every building, development, or remolding in the city, and for demolition projects
- Provides a plan review checklist, along with detailed administrative standards to ensure quality, state of the art tree protection on all sites.
- Provides a comprehensive tree species list for replacement canopy trees.
- Establishes a tree bank for developers and builders to pay into, when there is not enough room on their projects to plant the required trees. Funds in the tree bank are use by the city to plant trees in public spaces.
- Established a process for protecting trees on neighboring properties, whose roots or branches may cross over onto a site being developed.
- Conducts routine site inspections to insure compliance with the tree conservation plan. Final site inspections are conducted to evaluate tree conditions and ensure new tree plantings prior to the issuance of a certificate

Boundary Tree Requirements

Tree ordinances are beginning to require the inclusion of boundary trees in tree protection plans during permitting, and are requiring boundary tree agreements when trees are damaged or exceed an established impact threshold and are considered destroyed, (for example if 20% of the critical root zone is impacted). These agreements are attached to the city file copies of tree protection plans.

Where communities have staffing capacity, performance bonds are also tied to these agreements to cover treatments, tree removal, and replacement costs, in the event the builder no longer exists towards the end of the agreement period. See the sample boundary tree agreement in Appendix 1.

Part 3: Planning for Tree Protection

Know What to Expect

Effective planning for tree protection requires a comprehensive understanding of two broad categories of information: 1) every element of the construction design and implementation process, and 2) specific and detailed information about the trees. The overlay of these two categories begins to reveal the potential conflict between what is being proposed on the site, and the trees, and this sets the stage for the development of a tree protection plan. A list of the types of information that should be considered in each category is provided in Table 3. This information is also typically included in plans required by tree protection ordinances.

Table 3. Construction and Tree Factors to Consider

Construction Related Parameters	Tree Related Parameters
• Property boundaries • Topography • Existing drainage patterns • Foot print of proposed structures, and pavement • Proposed grading and drainage • Location of curb cuts and driveway aprons. • Location of underground and overhead utilities • Location of septic systems • Area for temporary storage of fill, material, or debris	• Identification of tree species and their location. • Tree size (dbh, height, crown spread) • Condition analysis including potential risk • Approximation of the tree's critical root zone (CRZ). • Measurement of lower crown elevation. • Canopy cover • Analysis of soil qualities (texture and drainage). • Tree exposure.

Most of this information is obtained during the early site design process of an infill development project. It should be noted that almost all of this information requires the professional services of surveyors, engineers, architects, and arborists. Therein lies one of

the most critical keys to effectively protecting trees during infill development: ***Active communication between design and engineering professionals and an arborist during all phases of design and construction.***

Site Design and the Tree Protection Plan

It is common for a building site design to be drawn without the inclusion of trees. When this occurs, the worst tree damage also occurs. Construction activity commences without regard for tree and tree root location, and there is no separation from the activities and trees.

There are two basic approaches to developing a tree protection plan. The first is a "passive" approach, where the site plan (layout, grading and utilities) is drawn, and a tree protection overlay is developed based on that plan. With this approach, trees protection is secondary to the site design, but this approach can separate construction activities from the remaining trees, and facilitate their survival. This approach is commonly followed in communities with tree protection ordinances, which *do not* establish minimum existing tree coverage requirements.

The second "active" approach is where the site plan and the tree protection plan are developed simultaneously and in coordination with one another. This allows for adjustments to the site layout, grading and utility locations to accommodate trees, and the consideration of special tree encroachment techniques. The active approach will optimize tree protection during infill development projects. Tree ordinances that have established a minimum tree coverage standard usually take this second more active approach. The next sub-section provides detail on the steps that should be taken in active planning. While instructional, this information could be included in a tree ordinance's guidelines to establish a uniform and effective tree protection planning process in the community.

10 Steps in Active Tree Protection Planning

1. Survey all the trees on site. This survey should include the species, size, location, condition (including any potential risk), and canopy analysis (sq. ft. of canopy and height of lowest limbs). This survey should also include a critical root zone analysis.
2. Survey the trees on adjacent properties whose critical root zone crosses over onto the project site. This survey should include species, size, condition and are of critical root zone, and should also note the elevation of any limbs crossing the property line.
3. Show all of the trees on project site plan (including the neighboring trees) with their exact locations and diagram their critical root zones.
4. Overlay the building footprint and other proposed structures (driveways, porches, decks, drainage structures, etc.)
5. Analyze the potential impact of the proposed structures as they might occur within the critical root zone of the trees. This analysis occurs between the site design

professional and the arborist, and considers several factors to minimize impact to trees and optimize tree protection:

a. What is the potential nature of the impact and how extensive might it be (typically expressed by percentages, such as: 15% of the CRZ may be impacted by cut roots for the excavation of footings for a foundation).
b. What is the condition of the tree(s) being impacted?
c. Are there some trees in poor condition, where tree removal in that location might allow relocating structures to reduce the impact of trees in better condition elsewhere on the site?
d. Is there any flexibility in the size, shape, and location of the proposed structures, which could reduce the impact to trees?
e. Can a variance process be employed that will allow flexibility with front, rear, and side setback lines, to reduce the impact to trees?
f. How are neighboring trees being impacted?
g. How are the limbs of the tree being impacted by the vertical height of proposed structures?
h. Are there special encroachment techniques, which might minimize the impact to trees?

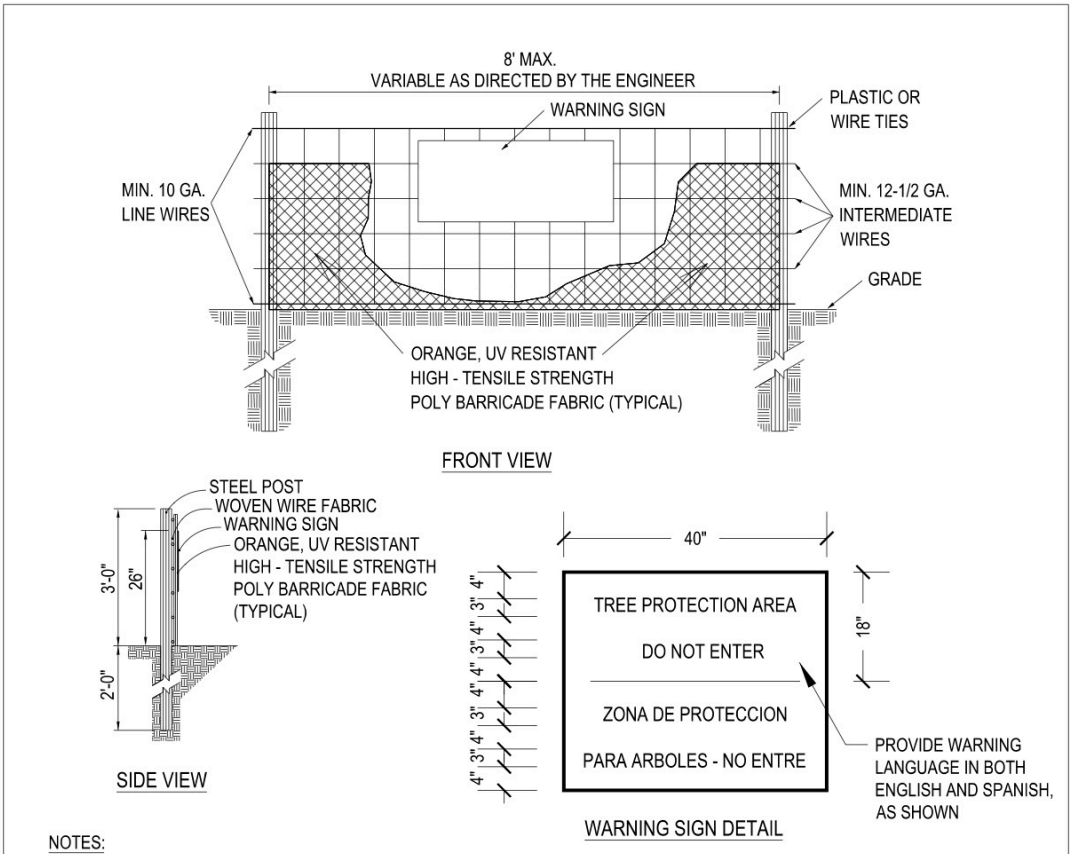
6. Locate any underground and overhead utilities, such as water, gas, sewer, electricity, and cable. Conduct a similar analysis as above to minimize impact to the tree's critical root zone.
7. Establish limits of disturbance based on the analysis in steps 5 and 6. Areas outside the limits of disturbance are referred to as the tree protection zone.
8. Identify staging areas for construction material storage, debris storage, parking, and any other incidental construction activity, outside the tree protection zone.
9. Separate the tree protection zone with tree protection fencing. Provide erosion control devices along the limits of disturbance, where the tree protection zone might be downhill from construction activity.
10. Provide detailed drawings of fencing, erosion control devices, and special encroachment techniques. Specific call-outs or notes should be included where appropriate. (For example; notes providing specifications for pruning if limbs my conflict with the proposed structure).

Critical Root Zone (CRZ) Analysis

One of the more difficult features of a tree to describe is the extent tree's critical root zone (CRZ). This zone is described as the minimum rooting area of a tree. Any disturbances within this zone begin to compromise the tree's survival and the greater the disturbance, the less likelihood for survival.

Because we can't see where roots are, and it's not practical to excavate soil to reveal the roots, the size of the CRZ is based on generalizations. The most common general description is a CRZ radius (in feet) based on the tree diameter (at 4.5 feet), with the assumption that the larger the tree, the larger the radius. For example, a 1-foot radius to a 1-inch diameter inch ratio would mean that a 30-inch diameter tree would have a 30-foot radius CRZ.

Most community tree ordinances define this ratio in a range from 1:1 to 1:1.5. Experienced arborist take these ratios and adjust them upward or downward according to soil types, tree species, vigor, size and condition.



NOTES:

1. TREE PROTECTION FENCING MUST BE INSTALLED AT A MINIMUM RADIUS OF THE CRITICAL ROOT ZONE (CRZ) OF TREES. (CRZ DEFINED AS RADIUS x 1.25' (FT) PER INCH AT DBH FROM TRUNK OF TREE, SEE TREE PROTECTION FENCE LAYOUT DETAIL)
2. IF CONSTRUCTION OCCURS WITHIN THE CRZ AT LEAST 12" OF MULCH AND/OR LOGGING MATTS SHALL BE PLACED WHERE MACHINERY MANEUVERS TO REDUCE SOIL COMPACTION IN THIS ZONE.
3. THE TREE PROTECTION FENCING MUST NOT BE VIOLATED FOR THE ENTIRE DURATION OF THE PROJECT WITHOUT APPROVAL FROM URBAN FORESTRY STAFF.
4. THERE WILL BE ZERO TOLERANCE FOR STORING OR PARKING VEHICLES, SUPPLIES, OR EQUIPMENT UNDER PROTECTED TREES.
5. IMPACT PROTECTION DEVICES MUST BE REMOVED AFTER CONSTRUCTION.
6. WARNING SIGNS TO BE MADE OF DURABLE, WEATHERPROOF MATERIAL. LETTERS TO BE 3" HIGH MINIMUM, CLEARLY LEGIBLE AND SPACED AS SHOWN.
7. SIGNS SHALL BE PLACED AT 50' MAXIMUM INTERVALS. PLACE A SIGN AT EACH END OF LINEAR TREE PROTECTION AND 50' ON CENTER THEREAFTER. FOR TREE PROTECTION AREAS LESS THAN 200' IN PERIMETER, PROVIDE NO LESS THAN ONE SIGN PER PROTECTION AREA.
8. ATTACH SIGNS SECURELY TO FENCE POSTS AND FABRIC. MAINTAIN TREE PROTECTION FENCE THROUGHOUT DURATION OF PROJECT.
9. A TREE IMPACT PERMIT IS REQUIRED.
10. ADHERE TO STANDARDS IN THE CITY TREE MANUAL.

CONTACT INFORMATION:
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CITY OF RALEIGH
PARKS, RECREATION AND CULTURAL RESOURCES DEPT

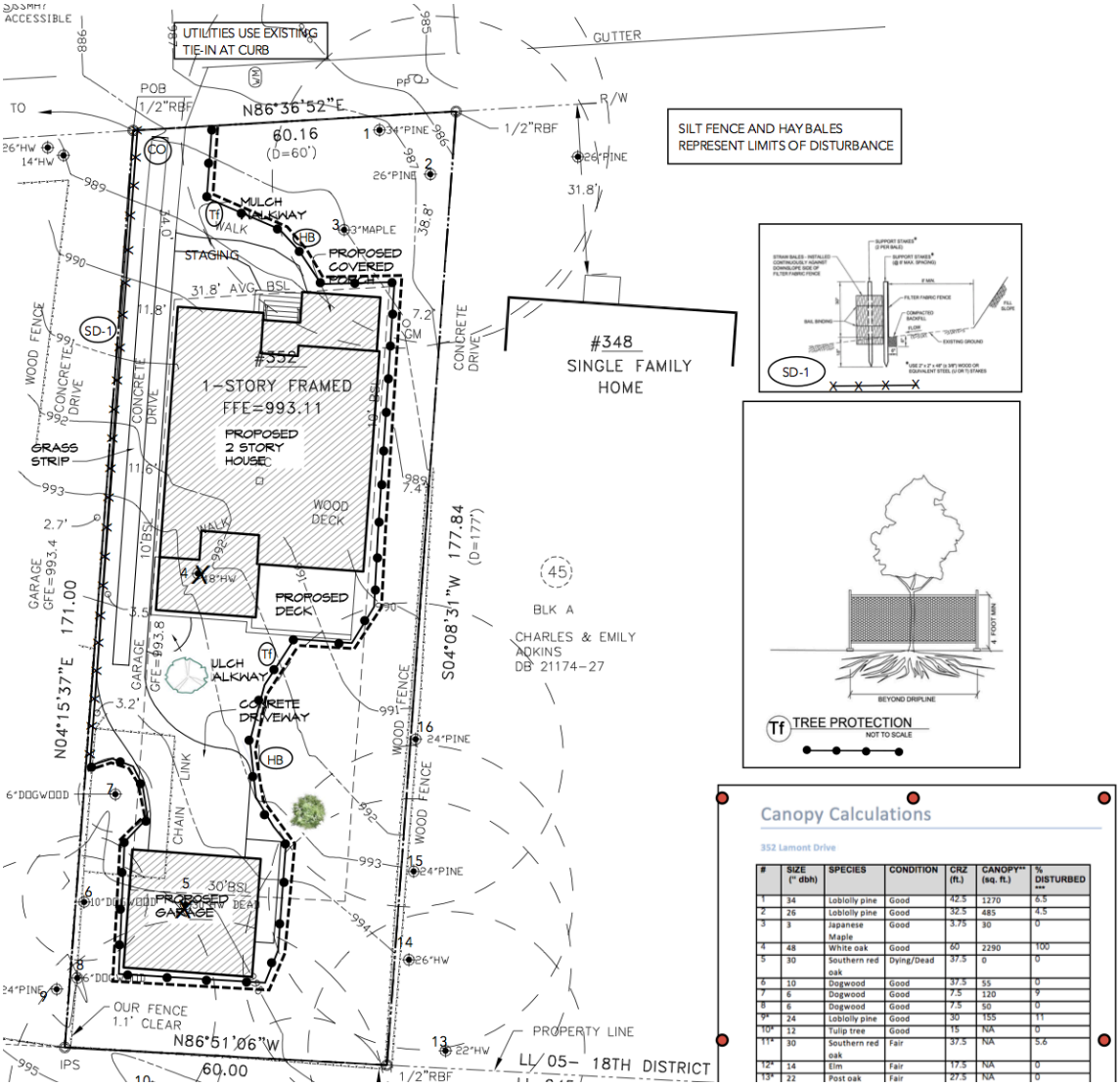
REVISIONS	DATE: 9/1/13	NOT TO SCALE
	TREE PROTECTION FENCE	
	PRCR-01	

Typical tree protection fencing detail used by the City of Raleigh, NC

Special Encroachment Measures

Infill development projects tend to be "tight", i.e. there is very limited space for the building, the trees, and all the other activities, which occur on site. As a result, special techniques must occasionally be utilized to allow potentially damaging activities, closer to the protected trees. A tree's response to construction damages depends on the species, its age, condition, and site factors, so an experienced arborist should be consulted prior to employing special encroachment measures. In some instances, the cost of the measure must be weighed against the values and condition of the tree. It may be more practical to remove and replace the tree. Following is a list of common encroachment measures:

- 4 to 6 inches of wood chip mulch covered by ¾ inch plywood would allow traffic and storage over the roots while preventing compaction
- Retaining walls can be used to reduce grading within the CRZ of trees, by tightening the grades or preventing cuts.
- Utilities can be bored underneath the roots (which typically occur within the topmost 3 feet of soil).
- Trenching for the installation of underground utilities in a radial pattern away from a tree trunk will minimize damage (as opposed to trenching horizontally through a root system.)
- Pervious driveways and walkways could be formed on the surface over roots, on top of a layer of 6 mil plastic sheeting and gravel.
- A clean cut with ditching/trenching equipment along the limits of disturbance prior to grading or for foundation or footing cuts will prevent tearing the roots of protected trees.



#	SIZE (" dbh)	SPECIES	CONDITION	CRZ (ft.)	CANOPY** (sq. ft.)	% DISTURBED ***
1	34	Loblolly pine	Good	42.5	1270	6.5
2	26	Loblolly pine	Good	32.5	485	4.5
3	3	Japanese Maple	Good	3.75	30	0
4	48	White oak	Good	60	2290	100
5	30	Southern red oak	Dying/Dead	37.5	0	0
6	10	Dogwood	Good	37.5	55	0
7	6	Dogwood	Good	7.5	120	9
8	6	Dogwood	Good	7.5	50	0
9*	24	Loblolly pine	Good	30	155	11
10*	12	Tulip tree	Good	15	NA	0
11*	30	Southern red oak	Fair	37.5	NA	5.6
12*	14	Elm	Fair	17.5	NA	0
13*	22	Post oak	Fair	27.5	NA	0

Screen shot of a portion of an active tree protection plan showing the delineation and separation of tree protection areas from the “construction envelope”.

Addressing Boundary Tree Issues

A common issue with infill development is the impact to trees sharing a property line (thus jointly owned by the builder and a neighbor) or on neighboring properties. This is especially the case in older neighborhoods undergoing housing renewal, when older homes are demolished and larger homes are built on small lots. Since this occurs in older neighborhoods, the adjacent lots often contain larger, more mature trees, whose roots extend into the lot being developed. These trees and their roots typically sustain damages from construction activities. Additionally, major limbs of these more mature trees often extend over properties being built on, resulting in conflict with the elevation of the proposed structures.

It is advantageous for both builders and impacted neighbors to recognize and address these boundary tree issues. As a neighboring homeowner, addressing these issues can protect you from costly tree removal costs or the subsequent risk associated from construction damaged trees. As a builder, addressing these issues protects you from the possible risk and liability of damaging a neighbor's property.

Boundary tree issues are best addressed through the tree protection planning process, so the trees, their crown elevation and critical root zones are identified and located on the tree protection plan, the trees are actively protected, appropriately pruned (for elevation where necessary), and any damages are appropriately mitigated.

It is also important to document boundary tree issues. This is best done through a "boundary tree agreement" between the affected neighbor and the builder. These agreements typically identify the tree(s) being impacted, the nature and extent of the impact, mitigating or prescriptive measures (arboricultural treatments) being taken, and the builder's willingness to pay for removal and replacement of the tree if it succumbs to construction damages (decline or death), over a stated period of time. Trees will generally react to construction damages within three years. An arborist evaluation of the boundary tree's condition prior to the commencement of site work or building construction, including photo documentation is recommended.

Trees on or near property lines (boundary trees) are often damaged from the construction activities on the adjacent properties.

Part 4 : Implementation

Following the Plan

Prior to the commencement of construction activities, it is advisable to have a conference with the project general contractor to discuss elements and implementation of the tree protection plan. If this plan is being implemented as a requirement under a tree ordinance, the pre-construction conference should be mandatory. During this conference the following factors should be discussed:

1. Phasing of activities. Tree protection fencing and erosion control devices should be installed according to the plan along the limits of disturbance and prior to the commencement of any activities on site. Sometimes builders request a delay in installation of the tree fencing if there is a demolition (of a pre-existing structure) involved, arguing that the demolition process could damage the tree protection fencing. This decision requires a judgment call. If demolition could damage the protective devices then it could also damage trees. Most tree ordinances required tree fencing prior to demolition.
2. Location of staging areas for debris, construction material, and parking.
3. Requirements for ongoing maintenance of tree fencing.
4. Responsibility for subcontractors. There are a variety of subcontractors typically involved with building construction. These include: grading contractors, concrete and foundation contractors, framers, electricians, drywall contractors, plumbers, roofers, and finishers, among others. It is likely that none of these contractors would be aware of any of the tree protection planning that has occurred, and it is the responsibility of the project owner or general contractor to make them aware. Adherence to the tree protection plan can be included as a clause in their contract. Some contractors will impose a fine if subcontractors violate tree protection areas. Signage indicating the tree protection areas and other staging area are also helpful. The use of bilingual signage may also be appropriate.
5. Instructions to call the city arborist immediately if there is cause for any deviation to the tree protection plan, before that deviation occurs.

The Need for Vigilance

Since there are a variety of contractors involved with the building construction process, it becomes critically important to constantly check, and recheck the integrity of the tree protection fencing and tree save areas. Catching encroachment into these areas early on can prevent potential long term, non-reversible damage to the trees. Communities with tree protection ordinances should build routine inspections into their implementation process. A city arborist can monitor projects as they routinely travel through the city. Some cities also train their building inspectors to check on the status of tree protection as they conduct their inspections. It is also useful to provide education programs to the community so neighbors can keep a watchful eye on tree protection.

The period where a construction project nears completion is particularly dangerous for the protected trees. This is when finishing touches occur such as Internet cable installation or landscape installation. Unknowing contractors could trench for cable or irrigation systems, or rototill the feeder roots of trees to prepare for sod. Lawn and trees are an incompatible mix, so it is best to plan for permanent mulch islands around trees.

Tree protection zones require constant monitoring because construction activities have a tendency to encroach.

More robust and effective forms of tree protection incudes chain link and post and rail fencing.

This tree was protected during home construction, but has suffered damage from trenching for an irrigation system.

Project Completion

Tree protection measures should remain in place until the construction project is completely finished. Once the tree fencing is removed it is a good idea to have the trees examined to see if they have sustained any damage and to take actions to mitigate those damages. For communities working with tree ordinances, this final inspection occurs prior to issuing the project's certificate of occupancy.

It may take two years or more for a construction damaged tree to begin to decline. An experienced arborist can predict a tree's response to construction damage, and prescribe treatments that could help a tree survive, although treatments are somewhat limited. A tree that has lost roots has also lost its ability to take up water and nutrients, so fertilizer treatments will have a limited effect. If there are severe damages within a tree's structural root plate, the tree may become a risk and removal should be considered. Damage to branches may be improved with proper pruning, while damage to the trunk may be corrected by removing loose and lifted bark. Tree can also be treated with pesticides to prevent attack from insects while in their stressed condition. The most effective post construction treatment involves steps to restore the soil environment with aeration, mulch and water during dry periods.

Appendix 1: Sample Boundary Tree Agreement

Date: _____

_____

Address of Owner or Co-owner of the tree:

_____

Address Where Construction Will Occur:

TO WHOM IT MAY CONCERN

I, _____ (print name) owner/co-owner of the tree(s) give _____ (print name) builder/developer permission to destroy or impact my tree(s) that straddle(s) the boundary of our property during construction activities.

Describe each tree by species, diameter at breast height, location, and if it destroyed or impacted:

Tree 1:_____

Tree 2_____

Tree 3:_____

CHECK WHICH APPLIES: may be one or both conditions:

[ ] FOR TREES DESTROYED: I have seen the site plan and am aware that the tree(s) is considered destroyed. If the tree(s) is/are removed, it will be at the expense of the developer/builder. You or the tree removal company must provide me with proof of workman's compensation and general liability insurance coverage, prior to tree(s) removal. This insurance shall cover any damage to my property during the tree removal process. Replacement tree(s), planted on my property, will be selected by me using the City's list of recommended trees.

[ ] FOR IMPACTED TREES: I have been provided with an arboricultural prescription . The prescription was developed by an International Society of Arboricultural Certified Arborist and accepted by the City. This prescription shall be implemented and cannot be cancelled, terminated, or otherwise modified without my consent and the approval of the City Arborist. I give the certified arborist or their designated contractor right-of-entry to my property to treat the tree(s) according to the prescription.

_____ _____

Print Name of owner/co-owner of tree(s) Print name of builder/developer

_____ _____

Signature of owner/co-owner of tree(s) & Date Signature of builder/developer & Date

Appendix 2: Sample Maintenance Bond

STATE OF _____

COUNTY OF _____

TREE MAINTENANCE BOND

This Tree Maintenance Bond is made, and entered into, this _____ date of _____ 201---, by and between: _____, hereinafter referred to as Contractor; Located at _____, and the City of _____, hereinafter referred to as Obligee, located at _____.

WHEREAS, this maintenance bond is held and firmly bound unto the City of _____, for the use and benefit of the City of _____, for potential required removal and replacement of the following Tree/s:
_____ located at _____, Shown on the Tree Conservation plans dated ____/____/____ approved by the Obligee; and

WHEREAS, this maintenance bond is required pursuant to the Unified Development Code Section _____ of the City of _____; and

WHEREAS, the maintenance bond shall be in an amount of _____ Dollars ($_____) which consists of the removal and replacement value for Tree/s in the amount of _____ dollars ($_____).

WHEREAS, the City of _____ has approved the Tree Conservation plan dated ____/____/____ for the project known as _____ located at _____; and

WHEREAS, this bond shall further guarantee the viability of Tree/s _____ for a period of three (3) years following the date of acceptance of said project by the City of _____; and

WHEREAS, prior to issuance of a certificate of occupancy (CO), the Contractor shall provide the City of _____ with a business check or third party maintenance bond in the sum of _____ Dollars ($_____) for the purposes of this maintenance bond and the City of _____ shall keep the funds in an escrow account for a period of three (3) years after acceptance of said project should the Tree/s _____ require removal and replacement as determined by the City of _____'s Arborist.

NOW, THEREFORE, the condition of this obligation is such that if the Arborist for the City of _____ shall deem Tree/s _____ to be poor or declining requiring removal and replacement during the period of Three (3) years following the date of acceptance of the project, the City of _____ shall notify Contractor in writing prior to warranty work commencing to remove and replace poor or declining tree(s). In the event that the trees do not require removal and replacement during the warranty period and upon approval from the City Arborist, The Contractor can then request that the City of _____ issue the Contractor a check within four (4) to six (6) weeks per City Clerk standard releasing the Three (3) year warranty period.

SIGNED AND SEALED, this _____ day of _____, 201--

Contractor: _____

By: _____

Print Name: _____

Title: _____

City of _____ , Department of _____

By: _____

Appendix 3: Glossary of Terms

- Boundary Tree
  Trees sharing a property line (thus jointly owned by two neighbors) or trees on neighboring properties with tree parts (roots and branches) extending over property lines. Boundary trees are potentially impacted by construction activities on neighboring properties being developed.

- Critical Root Zone (CRZ)
  This zone is described as the minimum rooting area of a tree. Any disturbances within this zone begin to compromise the tree's survival and the greater the disturbance, the less likelihood for survival.

- Diameter at Breast Height (DBH)
  The diameter of the trunk of a tree measured at 4.5 feet above the ground.

- Encroachment Measures
  Special techniques employed to mitigate the potential impact to tree while construction activity is occurring within their critical root zone

- Erosion Control Devices
  Tools that are used on construction sites to prevent soil from eroding off the site. Examples include silt fencing and hay bales.

- Limits of Disturbance
  A defined line on a construction site past which, no disturbance (grading, trenching, or construction) is going to occur. These limits are typically separated from construction activity with tree protection fencing and erosion control devices.

- Rezoning
  An administrative process employed by local levels of government to change a community's land use map. Examples include changing land use from residential to commercial, or increasing the density of residential land use.

- Staging Area
  An area on a construction site identifies specifically for the storage of construction debris and building materials. Staging areas are separated from tree protection areas to prevent damage to trees.

- Tree Canopy
  The spatial area formed by tree crowns; the extend of the outer layer of leaves of an individual tree or group of trees.

- Tree Impact
  A description of the nature and extent of damage to a tree or its parts, often described as a percentage of damage to that part. Example: 25% of the tree's critical root zone was impacted by the grading activities.

- Tree Protection Fencing
  A physical barrier erected to separate trees from construction activity. Tree protection fencing can be made of chain link fence, a hog wire/snow fence combination, ore wooden post and rail.

- Tree Protection Zone (TPZ)
  An area on a construction site that is separated from all construction activity and protected with tree protection fencing to prevent impacts to trees. Also referred to as a "tree save area"

- Variance
  A deviation from the set of rules a municipality applies to land use and land development; typically a these rules are typically contained within a zoning ordinance, building code or municipal code.

Additional Resources

The Benefits of Trees and Forests

http://naturewithin.info/

http://www.actrees.org/files/Research/benefits_of_trees.pdf

http://www.southernforests.org/urban/benefits-of-urban-trees

http://www.naturewithin.info/UF/TreeBenefitsUK.pdf

http://www.urbanforestrysouth.org/resources/library/citations/benefits-of-urban-trees-booklet/

http://www.earthshare.org/2013/07/treebenefits.html

The Biological Needs and Limitations of Trees

http://forestry.about.com/od/Treebiology/

http://www.arborday.org/trees/treeguide/anatomy.cfm

http://urban.elearn.sref.info/module-2/chapter-1/player.html

Basic Tree Anatomy

Trees and Construction

http://www.treesaregood.com/portals/0/docs/treecare/AvoidingTreeDamage.pdf

The Effect of Oil Spills on Trees

The Impact of Construction on Trees

Protecting Trees During Construction

Construction Site Planning

Tree Protection Ordinances

Tree Canopy Conservation Ordinance: Decatur GA

An Ordinance to Conserve Trees: Raleigh: NC

Charlotte, NC Tree Ordinance

Athens-Clarke County GA Tree Ordinance