A TEAM APPROACH TO AVOIDING AND MITIGATING CONSTRUCTION DAMAGE TO TREES

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High density projects often do not allow for as much space as we would like. However, with a healthy, construction-tolerant species, specialized construction techniques, stringent controls and monitoring during construction, optimum tree care, success is possible. This is a native valley oak in a downtown area. Previous use was a bank and parking lot. Site was demolished and rebuilt. All images courtesy of HortScience, Inc.

Property development is a difficult process that can become even more complex when tree preservation is involved. Yet, trees offer valuable benefits – environmental, economic and social. With increasing frequency, trees on development sites become symbols of the commitment of a developer to the environment and the community.

Successful tree preservation is measured over the long term, when trees continue to thrive for many years after development. Successful tree preservation occurs when:

- healthy, structurally sound trees are selected for preservation;
- adequate space is planned for tree protection during the project design phase;
- trees are protected from damage during construction;
- everyone involved in the project is committed to protecting trees.

If tree preservation is to be successful, the arborist needs to be involved as part of the development team. The arborist's job is to bring knowledge about the tree resource and how it will respond to site development to the planning and design table. This requires interacting with the developer, engineers, architects and construction personnel, and reviewing and responding to plans throughout the development processes.

The tree preservation process

The sequence of events that results in successful tree preservation is intimately linked to the development process itself. From an arboricultural standpoint, the preservation process consists of the following steps:

1. Select healthy, structurally sound trees.
2. Design the "right space."
3. Prepare the trees for site change.
4. Protect from excessive damage during construction.
5. Maintain trees with long-term, low-intensity treatments.

Select healthy, structurally sound trees

Evaluating the suitability of individual trees or stands for preservation is one of the most important tasks for the arborist. Furthermore, this analysis is needed very early in the planning process. Designing projects around trees not suitable for preservation can waste considerable time and expense.

An assessment of suitability for preservation integrates tree health, structure, age and species factors. Trees that are structurally unsound, in poor health or unable to survive construction impacts are a liability to a project rather than an asset. When identifying trees that are suitable for preservation, consider the following four factors:

- Tree health

Healthy, vigorous trees are better able to tolerate impacts such as root injury, demolition of existing structures, changes in soil grade and moisture, and soil compaction than are non-vigorous trees.

Avoid retaining trees with significant structural defects where damage or injury would occur if they failed. The extensive trunk cavity at the junction of the scaffold branches is a defect that makes this tree unsuitable for preservation.

- Tree structure

Trees that contain significant defects that cannot be managed and are likely to lead to failure should not be preserved in areas where damage to people or property could occur.

- Species

Tree species vary both in their tolerance to construction activities and their ability to adapt to site changes. For instance, holly oak (*Quercus ilex*) and plane (*Platanus x acerifolia*) are relatively tolerant of construction impacts while European beech (*Fagus sylvatica*) is not.

Another species consideration is its potential to become an invasive weed. Where natural habitats are at risk from degradation should the exotic tree escape into nearby wild lands, replacement with non-invasive species should be considered. As an example, it may be unwise to plant tree-of-heaven (*Ailanthus altissima*) in locations where it is likely to spread.

▸ Potential longevity

Over-mature trees are less able to tolerate construction impacts than are young and mature individuals.

Declining and structurally unstable trees often have habitat value, but those trees should be retained only in areas where their structural failure would not impact people and structures.

Design the "right space"

The "right space" is one that provides adequate space and site conditions to sustain tree health and structural stability over time. The "right space" considers how the tree size and form will change over time as the tree grows. The "right space" must be planned for during the design phase of the project.

Project design is at first conceptual in nature, and becomes more detailed as plans are refined. The arborist participates in the design effort at first by identifying which trees are suitable for retention and the amount of space needed for adequate protection. The next step is to determine what impacts will occur and how the tree will respond. Then, if development constraints will not allow as much space as advised, the arborist may suggest design modifications to reduce the impacts. If impacts cannot be reduced, the arborist must determine whether the tree is unlikely to survive and should be removed.

Communicating with design professionals

If we are to be successful in preserving trees we must understand how development occurs. The simple fact is that structures, be they buildings, roads, patios or utility trenches, must be built in such a way that they are stable and safe. Therefore, specific engineering standards regarding soil compaction, footing and foundation design, and depth and separation of utilities must be attained. In many situations, the building standards and local codes allow limited flexibility for modification. The arborist usually must work within these requirements.

The most important aspects of construction for the consultant to understand are those that occur below ground. The soil (or geotechnical) engineer and the civil engineer largely determine requirements for these activities. The arborist should become familiar with common terminology and work procedures involved in these processes.

Identifying a tree protection zone

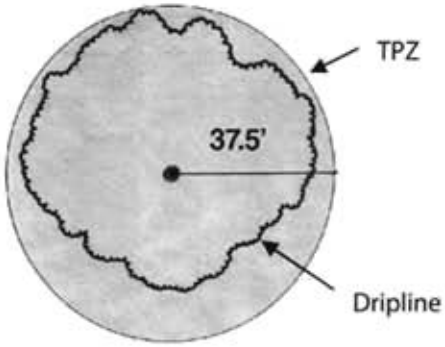
The tree protection zone (TPZ) is the area around the tree or groups of trees in which no grading, excavation or construction activity is to occur. The size and conformation of the TPZ depends on several factors including:

- ▸ species sensitivity to impact
- ▸ health and age of the tree
- ▸ root and crown conformation
- ▸ development constraints

In some situations the canopy form may dictate the conformation of the tree protection zone. Where large, low limbs are present that cannot be removed without disfiguring or damaging the tree, the tree protection zone must encompass those limbs.

Table 1:
Guidelines for adequate tree preservation zones for healthy, structurally stable trees.

Species tolerance to impacts	Tree age	Distance from trunk feet/inch trunk diameter
Good	Young <¼ life expectancy	0.5
	Mature ¼-⅔ life expectancy	0.75
	Overmature >⅔ life expectancy	1.0
Moderate	Young	0.75
	Mature	1.0
	Overmature	1.25
Poor	Young	1.0
	Mature	1.25
	Overmature	1.5



Root conformation is typically the hardest component to assess. Our model of tree root systems describes roots as being shallow – most within 3 feet of the surface – and extending far beyond the dripline. Actual root systems often deviate from this model. Some trees root quite deeply depending on the genetic makeup of the tree and the soil profile. In built environments, underground utilities and structures affect root distribution. It may be necessary to determine where roots actually are growing when defining a tree protection zone. Excavating with hydraulic or pneumatic tools can help identify root conformation so adequate space can be designed.

Tree Protection Zone guidelines based on tree size, age and species tolerance are provided in Table 1. When applying these guidelines, the usual variables must be considered – crown density, tree height, exposure to wind, lean, presence of other defects such as decay, soil depth and strength. A larger area than that calculated may be needed for stressed trees or those with low branches that extend outside the zone that need to be protected by temporary fencing.

Try as we might, projects usually are not designed with space for trees as the primary consideration. Space is at a premium on development sites, and compromises may have to be made with tree protection zones. It seems generally accepted that roots up to 1 to 2 inches in diameter may be cut without causing irreparable damage. It is unacceptable to cut into the buttress flare.

The guideline for maintaining health has been that we can remove 30 to 50 percent of the roots of most trees. Determining when that point is reached requires know-

Pneumatic or hydraulic tools can be used to remove soil around tree roots to determine their number and size, to expose them so they can be cut with a saw, or to thread pipes or conduit under them rather than cutting.

ing the full extent of the root system, which is difficult to accurately assess. In our experience, the minimum tolerated is highly species dependent. For instance, ash will tolerate much more root removal than walnut.

To calculate the optimum tree protection zone:

1. Evaluate the species tolerance of the tree: good, moderate or poor

2. Identify tree age: young, mature, overmature

3. In Table 1, find the distance from the trunk that should be protected per cm of trunk diameter.

4. Multiply the distance by the trunk diameter to calculate the optimum radius (in meters) for the tree protection zone.

5. Plot the radius on the tree preservation plan.

Example:

Healthy, mature, 30-inch diameter black walnut

1. Species tolerance =	poor
2. Age	mature
3. Distance =	1.25'
4. 1.25 ft. x 30 in. =	37.5' radius
5. Plot radius	

Evaluation of impacts to trees

It is virtually impossible to retain trees on a construction site without the trees incurring some degree of either injury or change in their environment. A reasonable goal, however, is to hold the impacts to the minimum that the trees can tolerate. When impacts are too severe, either the plans must be changed or the tree removed.

The type of construction that will occur around existing trees and how it will be executed has a great influence of tree survival and growth. By thoroughly examining construction plans and specifications, communicating with the project's design professionals, and corroborating the information in the field, the arborist can get a clear picture of what changes to the site will occur. In fact, the arborist must understand those changes long before construction begins. Once plans are finalized there is limited opportunity to significantly reduce impacts around trees.

Impacts to trees are cumulative. Rarely does the tree experience just one impact that affects its growth. Rather, a series of changes occur to which the tree must respond and adapt. The challenge for the arborist is to determine when impacts will be too severe for the tree to survive, not only in the short term, but also in the long term. That point depends on several factors including the severity of the cumulated impact and the ability of the individual tree to survive them, given the species, age and condition of the tree.

Minimizing tree impacts

Because in most cases we cannot completely eliminate construction impacts to trees, our goal is to minimize injury to a tolerable level. There are a number of ways this can be accomplished, depending on the specific conditions and requirements at the site. First, and foremost, *the goal is to protect trees rather than repair injury.*

Following are a few techniques to minimize tree injury during construction:

- *Fence trees prior to demolition or grubbing*

  The most effective fencing is chain link with posts sunk into the ground. Fences should enclose the tree protection zone, and remain until all construction activity is completed.

- *Minimize soil compaction*

  Limit traffic and storage areas

  Protect soil surface with deep mulch

  Specify minimum compaction on non-load bearing areas

  Use extra reinforcement in paving materials

  Avoid use of heavy equipment around trees

- *Minimize excavation*

  Maintain natural grade around tree

  Use discontinuous footings on retaining walls

  Modify paving materials to reduce

depth of section

Route utilities around trees, combine utilities in one trench

Lay irrigation lines on soil surface, cover w/ mulch

Tunnel lines rather than trench

Use pier foundations with grade beams above grade rather than slab foundations

▸ *Minimize changes in water supply and drainage*

If there are changes, attempt to reproduce 'natural' conditions through maintenance

▸ *Minimize pruning*

Consider location of low limbs when designing structures/uses under trees

▸ *Minimize competition*

Avoid planting and irrigation under sensitive native trees.

Control growth of competitive plants (e.g. vines, understory plants)

Prepare the trees for site change

Preparing the trees for site change involves two types of activities: alleviating stresses that degrade health and vitality, and providing clearance for construction.

Alleviating stresses

Trees may be under stress before construction even begins. The property may have received minimal or no maintenance prior to project approval. When evaluating trees before construction begins, the arborist should assess whether trees are affected by drought stress, limited nutrition and pests. By alleviating these stresses before construction begins, the trees are better able to respond to site changes. Consider if irrigation, fertilization, mulching or pest management are needed and discuss treatments with the owner/developer.

Provide clearance for construction

Crown and/or root pruning may be needed to allow access for construction equipment and activities. It is better for the arborist to prune properly before construction begins to avoid "pruning," either accidental or intentional, by construction workers.

Crown pruning should be performed according to standards — ANSI Z133 and A300 standards, and the associated ISA Best Management Practices – Tree Pruning. Where only temporary clearance is required, for instance for access by equipment, it may be possible to tie back branches rather than remove them. At least 5 feet of clearance from structures usually is required for construction. The amount of vertical clearance needed varies, but usually it is approximately 8 feet over sidewalks and 14 feet over roads. Required distance will vary with the type of construction equipment to be used, so discuss needs with the project superintendent.

Root pruning before grading or excavation for foundations or footings will avoid wrenching and shattering roots by grading and construction equipment. This is accomplished by cutting roots outside the tree protection zone to the necessary depth. Roots can be cut by digging a trench (manually or with high pressure air or water) and cutting exposed roots with a saw, a vibrating knife, rock saw, narrow trencher with sharp blades or other root pruning equipment. Cut the roots at right angles. After the roots are severed, grading and construction equipment can operate outside the tree protection zone without further damage. Avoid cutting sinker roots or roots larger than 2 inches in diameter.

Protect from excessive damage during construction.

We have limited ability to repair damage done to trees, so we must focus on protecting them from damage. The single most important tree protection treatment is a sturdy fence located at the limits of the tree protection zone that excludes construction activity from the tree.

The arborist's role during construction

The players present on a project change as it moves from design to construction. The arborist can provide important continuity among these changes.

The amount of time the arborist should spend on the site during construction varies widely. If, for instance, large tree protection zones have been established and defined with sturdy fencing, there may be little need for the consultant to be at the site. On the other hand, if equipment must maneuver close to trees, the consultant may need to be present to help determine appropriate work procedures and protection measures.

A few suggestions about working with superintendents…

▸ Schedule the site visit in advance. Unless there is a good reason to do so, avoid just "dropping in." There may be

other activities that prevent the superintendent from spending time with you.

▸ Check in with the superintendent when you first arrive on-site.

▸ Direct comments and suggestions about sub-contractors to the superintendent. Managing the subs is the superintendent's responsibility.

▸ Whenever possible, accentuate the positive.

Arborists commonly have five tasks during the construction phase:

1. Protect the Tree Protection Zone.

Maintenance of the TPZ may be the most significant activity associated with the post-design phase. Space is often at a premium on construction sites and the open areas defined by the TPZ are attractive locations for all sorts of activities.

2. Assist with changes in the field.

Few projects proceed without changes in the field. This occurs for a variety of reasons. For example, plans and field situations may not match. Or, an item may have escaped notice or was not discovered until construction. The consultant must participate in the decisions when conditions or plans change.

A note about availability: most construction projects don't have the luxury of time. Problems must be addressed and resolved quickly. For this reason, we must be responsive to requests for our time.

3. Monitor injury to trees and provide corrective action.

Few projects proceed without some injury to trees. Plans and changes may require work within the TPZ. The consultant must be prepared to recommend mitigations and corrective actions where damage has occurred, be it pruning, irrigation or other treatment. For example, the inadvertent piling of soil within the TPZ can quickly be corrected by removing it, without long-term consequences to the tree.

4. Communicate with the project superintendent.

In our experience, one of the most critical factors in the success of a tree preservation project is the commitment of the project superintendent. The arborist must help him/her understand the need for tree protection. We must also acknowledge the range of demands placed on the superintendent to complete the project and be respectful of the challenges they face.

5. Facilitate completion of the project.

Once the project has been approved by the public agency, consultants and arborists should be assisting in its completion in a timely manner.

What to look for during monitoring

▸ Ensure the integrity of the tree protection zone

- Tree protection fences intact
- No storage of materials
- No parking
- No dumping
- No evidence of soil or understory disturbance in protected area

▸ *Note any tree injury that occurred*

- Damaged branches from equipment
- Cut, injured or exposed roots
- Unapproved activity near trees

▸ *Look for unusual changes in tree appearance. Provide recommendations for treatment*

Leaf color, density
Wilting
Checking, bleeding on bark
Pest activity

- *Confirm that previously recommended treatments have been applied*

Tree care (irrigation, pruning, mulching)
Work procedures (root pruning, demolition & excavation methods)
Design changes

- *Address new questions/conflicts*

Additional pruning for clearance
Design changes
Work procedure changes

- *List new action items*

Tree treatments
Fence repair
Soil projection

Maintain trees with long-term, low-intensity treatments

At some point the developer will relinquish ownership/control of the project. The new managers may be individual property owners, a community association, the public agency or some other group. The transfer usually is preceded by an on-site inspection, often with remedial action required.

The arborist may be asked to update information in the tree survey or report, provide a list of actions taken during construction, or prepare a detailed post-construction maintenance plan. The nature of any work is determined by the needs of the new owners, specific tree condition and needs, and location regulations.

The effects of construction activity on tree health and stability may not be evident for some time. Trees must be inspected regularly for vigor, pests and structure. Follow-up treatments may include:

- Pruning
- Irrigation
- Mulching
- Pest management
- Fertilization
- Fire management (fuel loads, ladders)
- Removal of damaged or unstable trees.
- Replanting

While arborists like to think of common tree care practices as being solely positive, the reality is that some of our efforts may have negative effects on trees. Treatments such as transplanting, excessive fertilization, over-irrigation, pruning and some pest management treatments can be stress factors.

Determining root distribution in build environments can be difficult. Pavements, walls and foundations affect root distribution of trees near them. The roots of this pine are confined by the retaining walls surrounding it.

Therefore, our programs of care should minimize sudden change around the tree to the extent possible. Treatments should be tailored to the needs of the tree and provided in small doses over the long-term. Think about providing a stable environment. Anticipate a slow response by the tree.

Conclusion

Successful tree preservation occurs when the goals of the project are achieved with minimal impact to trees designated for preservation. Success is measured over the long-term, when trees continue to thrive for many years after development is completed. For that to happen, arborists making decisions about tree preservation must be knowledgeable in several areas. First, they must understand how trees grow, as individuals and in groups. Second, they must understand the process of development and methods of construction. Third, they must understand how trees respond to changes in the environment imposed by development of the land. Finally, everyone involved on a project must acknowledge that tree preservation requires a commitment by members of the community and the project team.

The authors are principals of HortScience, Inc., an arboricultural consulting firm located in California. They are authors of Trees and Development: A Technical Guide to Preserving Trees during Land Development, *published by the I.S.A. This article is based on a presentation by Nelda Matheny at TCI EXPO 2006 in Baltimore, Md.*