# Title:Preserving Trees During Construction: A Look at the<br/>Bender Oak and How it May Be Sheltered From Impending<br/>ConstructionAuthor:Ari Miller, -Arboriculture InternDate:August 2003

# Abstract:

New accessibility laws for people with disabilities have required the Arboretum to install a new path from the parking lot to the Widener Visitors Center. The installation of this path as planned could potentially threaten the health of the Bender oak by disturbing its root system. A more specific study is needed to determine ways to implement this path with low impact to Bender oak.

This project will address the ways that trees can be harmed during construction and it will provide some suggestions for methods of construction that are less dangerous to trees. This project will explore the various techniques employed in preserving trees during construction.

A series of alternative design schemes will be generated in an attempt to find the best solution. These schemes will each use different devices to reduce the impact of the path on the tree. The end product will be a comprehensive set of suggestions that the Arboretum can use to implement the new path in a conscientious way.

# TABLE OF CONTENTS

| Introduction                          |    |
|---------------------------------------|----|
| The Bender Oak                        | 3  |
| The Threat                            | 4  |
| Types of Damage                       | 4  |
| Understanding a tree                  | 5  |
| Assessing The Bender Oak              | 6  |
| Calculating The Root Protection Zone  | 7  |
| Implementing the Root Protection Zone | 8  |
| Alternative Solutions                 | 8  |
| Alternative paving Detail             | 9  |
| Previous Design Scheme                | 10 |
| Alternative Scheme 1                  | 11 |
| Alternative Scheme 2                  |    |
| Alternative Scheme 3                  |    |
| Conclusion                            |    |
| References                            | 14 |

#### **INTRODUCTION**

As we step beneath the canopy of an ancient tree our mood is suddenly altered. Branches and leaves create a unique enclosure that soothes, and inspires us in a way that no man made construction can. Trees single handedly create irresistible spaces that change, marking the passage of time, and yet they instill us with the sense of a place of permanence. How does one assign a value to such a commodity in the landscape? Is it more valuable than a convenient parking lot or a building addition? In many instances the value of a tree is forgotten in favor of development and existing trees are not considered during the construction process. The impact of a tree is often taken for granted and its absence is not fully acknowledged until it is gone.

There are many scenarios in which trees do not need to be sacrificed in order to complete the desired construction. When existing trees are retained, new developments fit in to the landscape more gracefully. Even unattractive, sterile architecture can be made to look more at ease with its surroundings if an old venerable tree stand is allowed to remain. Existing trees on a site should always be acknowledged and assessed as part of the early stages of the design process. It is not feasible to preserve all trees in a construction site; however, the decision to remove or keep a tree should never be an after thought. Many provisions must be made in order to properly preserve a tree during any sort of construction. All those involved in the construction process must understand a certain level of the biology of trees and be able to guide their actions based on this understanding. A designer may have noble intentions to save every existing tree on a lot, but if that person does not understand the needs of a tree a potentially dangerous situation may arise. Good intentions must be accompanied by informed decisions.

Too frequently trees that are supposed to be spared are unintentionally killed by an uninformed decision or careless behavior. Standing trees that have been killed by construction can then become potential hazards and a great deal of effort and money must be expended to remove them after the construction is completed. Financial set backs and physical hazards can seem insignificant, however, in those cases where the loss of a particularly old or historically significant tree is utterly tragic. Some trees are so irreplaceable and so cherished that they cannot be put at risk for any reason.

#### THE BENDER OAK

At the Morris Arboretum of The University of Pennsylvania in Philadelphia there are many such trees and one of the most valued among them is a particular bender oak (*Quercus X benderi*) that stands near the site of the old Morris mansion. This awe-inspiring tree greets visitors as they walk from the parking lot in to the garden; its massive presence captivating all who pass by. Its sheer size is a testament to the age of the Arboretum and it provides visitors with a sense of the history of the place.

Indeed this tree does have historical significance with regard to the Morris Arboretum. The age of the tree has not been determined, however it appears on the atlas map (A comprehensive plan of the Morrises' property) that was drafted at the turn of the century. On this map the tree can be located next to the original entrance road very near the Morris mansion. The tree appears to already have a sizable trunk diameter and is labeled as *Quercus coccinea*, the scientific name for scarlet oak. The misidentification and apparent size of this tree on the atlas map may suggest that it existed even before the Morrises' arrived. This tree has potentially

witnessed the construction and destruction of the Morris mansion and the transition of the land from private estate to prominent public institution.

#### THE THREAT

It is undeniable that this tree is utterly invaluable and must be protected at all cost. This is why a proposal for a new path that treads on the toes of this marvelous tree must be put under the utmost scrutiny. The proposal calls for a new pedestrian walkway from the parking lot to the visitor center in supplement to the existing one that will meet the updated standards for handicap accessibility. A wider more gently sloping path must be achieved in order to be compliant with the law and to better accommodate our handicap patrons. This minor yet necessary construction project seems as if it would pose little threat to the gigantic bender oak, but there are many unsuspected ways that a tree can be harmed.

No matter how minute a construction project is there is always some impact to the land and the trees on it. Trees can be affected directly and/or indirectly by a given construction process. In general there are three categories of ways a tree can be damaged during the construction process; a tree could be damaged above ground, below ground, or through changes in the environment.

#### **TYPES OF DAMAGE**

Above ground damage is easy to avoid, easy to spot, and generally easy to treat. Examples of this would be broken limbs or wounding of the bark layer. This sort of damage occurs through sheer carelessness during the actual construction phase. Operating vehicles and heavy machinery too close to the tree and piling materials against the trunk can cause this sort of damage. Broken limbs can receive pruning cuts and wounds to the bark will often heal but the infractions that cause above ground wounds are often signs that the tree has been impacted more severely below ground.

Below ground damage is much harder to avoid because the location of tree roots is not always obvious and virtually all traditional construction practices are potentially harmful to a tree if they are carried out in areas where tree roots are. Whether the project is to erect a building, install utilities our put down a paved pedestrian path, some sort of digging is inevitably part of the process. Digging of any sort within a root zone is sure to sever roots. Cutting significant roots may cause a tree to die 5 years down the line or it may cause a tree to fall in the next windstorm depending on how close to the tree the roots have been severed. Even if there is no digging, tree roots can be damaged simply by driving heavy machinery too close to a tree. This machinery can crush roots and compact the soil.

Soil compaction is categorized as an environmental disturbance and is often just as devastating to a tree as severed roots. When the soil is compacted roots cannot perform the necessary gas exchanges needed for healthy root growth because the number of micro pores in the soil has been reduced. It is also harder for roots to penetrate into more hard packed soil. The effects of compaction are long lasting and very difficult to reverse.

Filling soil on top of a root system can sometimes have a similar effect on a tree that compaction does. If tree roots are buried too deep they may be suffocated and cut off from water that is percolating less easily through the extra media. Although filling on top of tree roots can be

harmful it is far less detrimental than cutting roots or compacting soil. The negative effects of fill can be greatly reduced if attention is paid to the specific type of material that is being amassed on the root zone.

Trees are sensitive to their environment above ground as well as below ground. Any alteration in the landscape that results in a change in microclimate can potentially be detrimental to a trees' health. Removing adjacent trees or erecting a building can change light conditions, temperature, wind conditions and other attributes of the microclimate to which a particular tree has become accustomed. For example; when housing developments are built in wooded lots and the developer plans to save one or two trees in the front yard of every housing unit the effort is almost always unsuccessful. This is largely due to the fact that these trees have grown in response to a woodland setting and are not suited to standing alone unprotected from wind and direct sunlight. It is important to note that trees rarely exhibit the attributes of an unhealthy tree immediately after they have been harmed in any way. It can sometimes take many years before the canopy shows any signs of the damage that has occurred.

## **UNDERSTANDING A TREE**

Being aware of the types of damage that a tree can suffer during construction is helpful when attempting to save a tree, however, this knowledge is almost useless if one is not familiar with the physiology of a tree. There are many widely disseminated myths about how trees look beneath the soil. One of the most popular of these is the notion that trees look the same below ground as they do above. That is to say that the root system is a mirror image of the canopy underground. This could not be farther from the truth. For one thing tree roots very seldom go deeper than three feet below the soil, with the vast majority within the top eighteen inches. Roots also almost always extend far beyond the drip line of the canopy, up to two or three times the diameter of the canopy spread. In the past many construction projects that include tree preservation have used the drip-line as the tree protection zone. Often these trees have lost significant portions of their root mass and have been placed under extreme stress which could ultimately kill them.

Another common misconception is that tree roots grow in a circle. Roots are opportunistic and will proliferate in areas where growing conditions are most suitable. This results in an irregular shape below ground with farther-reaching, more vigorous roots in more permissive soil. Roots also respond to hard packed soil and other below ground barriers by growing more slowly into these areas or by directing growth along the barrier.

One must be aware of the different kinds of roots in a root system and be familiar with their functions. The large rapidly tapering roots closest to the tree are called the structural roots. These roots are woody with a bark layer like the trunk of the tree and their main purpose is to anchor the tree to the ground and keep it standing. These roots are not responsible for absorbing water and nutrients or exchanging gases but rather provide a structural framework below ground from which the rest of the root system sprouts. Structural roots taper down to cylindrical fleshy roots often referred to as ropey roots, which act as pipelines carrying water and nutrients from more distant parts of the root system back to the tree. The workhorse of the root system is the fibrous root. These thin fleshy roots are solely responsible for absorption and the expansion of the root system. They sprout from all of the other types of roots like little hairs. These roots are quick to regenerate but that does not mean that they should be ignored when protecting a root zone.

## **ASSESING THE BENDER OAK**

Along with the knowledge of trees in general one must know the specific attributes of the tree that is to be preserved. In our case we must assess the threatened bender oak in order to learn how to best protect it. *Quercus X benderi* is a naturally occurring cross between scarlet oak (*Quercus coccinea*) and red oak (*Quercus rubra*). This tree is distributed in the United States mostly in Pennsylvania and Massachusetts. Our particular Bender oak is approximately 75' in height with an impressive canopy spread of 100' in the north/south direction and 111' in the east/west direction. The diameter of the trunk at 2' above ground level is 76". This base information can now be used to approximate how far the root zone extends into the surrounding area. In the book "*Trees and Development*" by Matheney and Clark, a system is outlined through which we can gain an educated estimate of the root spread of almost any tree. First we must evaluate the tree species to determine whether its' tolerance to construction disturbance is good, moderate, fair or poor. We can do this by finding out what others have observed about the tree species.

In the case of the Bender oak very little is known about its' tolerance so we must look at the two species that it is a cross of. Tree experts Coder, Hightshoe and Sydnor comment on *Quercus rubra* saying that this species has moderate to good tolerance with a response dependant on soil aeration and water availability. *Quercus rubra* is said to have poor to moderate tolerance by S. Clark and Sydnor, however Coder disagrees stating that in his observations he has seen this species exhibit a good tolerance. With all of this conflicting information it is hard to gauge how tolerant our Bender oak really is. In assessing this tree I chose to calculate root protection zones for the two levels of tolerance (moderate and good) that were mentioned most frequently in reference to the two species of oak.

The formula calls for us to also classify the tree into an age category labeling it as young, mature or over mature based on the estimated percentage of its life expectancy that is already completed. The age of a tree has a bearing on how resilient a tree is and therefore how well it will respond to stress. Just like young people, young trees tend to heal faster. The Bender oak has almost certainly completed more than 80% of its life expectancy and therefore falls easily in to the category of over-mature trees. This indicates that the protection zone will most likely need to be fairly extensive.

#### CALCULATING THE ROOT PROTECTION ZONE

With these assessments and the measurement of the trunk diameter we can now calculate the recommended protection zone for the tree we intend to protect.

| SPECIES TOLERANCE | <u>TREE AGE</u>                       | DISTANCE FROM<br>TRUNK<br>Feet (Per Inch Trunk Diameter) |
|-------------------|---------------------------------------|--|
| GOOD              | YOUNG<br>(<20% life expectancy)       | 0.5'   |
|                   | MATURE<br>(20-80% life expectancy     | 0.75'  |
|                   | OVER MATURE<br>(>80% life expectancy) | 1.0'   |
| MODERATE          | YOUNG                                 | 0.75'  |
|                   | MATURE                                | 1.0'   |
|                   | OVER MATURE                           | 1.25'  |
| <u>POOR</u>       | YOUNG                                 | 1.0'   |
|                   | MATURE                                | 1.25'  |
|                   | OVER MATURE                           | 1.5'   |

Using the "good" rating for an over-mature tree we find that we must go 1' from the trunk for every inch of trunk diameter. With a trunk diameter of 76" we find that we need a 152' diameter circle for our protection zone. This is one and a half times the canopy spread. If we calculate a protection zone using the "moderate" rating we find that a 190' diameter zone is needed; almost twice the canopy spread.

Both of the calculated circular protection zones encompass very large areas that would be difficult to navigate a practical path around. However, as was stated earlier, tree roots do not grow in a circle. We must look at the history of the site around this tree in an effort to come up with some hypotheses as to where the roots may be most abundant. The current driveway to the visitor parking lot is encompassed by both of our calculated protection zones, however it is doubtful that the roots on the roadside of the tree have been as vigorous as those elsewhere. In the days of the Morrises' the entrance driveway for the mansion came even closer to the Bender oak on this same side. The disturbance from the construction involved in creating both of those roads not to mention the years of compaction from traffic must have weakened and stunted the root system on this side of the tree. A more accurate root protection zone would show a recession in the circle near the area of the driveway.

#### **IMPLEMENTING THE ROOT PROTECTION ZONE**

Now that we have a protection zone we must decide how to address it and respect it. The safest thing to do would be to restrict all construction activity from entering the protection zone. This means that no vehicles or workers would be allowed to enter into the zone for any reason. Also all machinery and materials must be stored outside the zone. In order to achieve this, formidable yet temporary barriers would have to be erected and all work would have to be supervised by an Arboretum staff member to insure the sanctity of the protection zone. In most situations this is the best way to insure the safety of a tree however in some situations this is not entirely practical. In fact it is questionable whether this is the right approach for our particular scenario.

#### **ALTERNATIVE SOLUTIONS**

Alternative construction practices can sometimes allow us to tip toe over sensitive protection zones. In this particular case we are dealing with alternative methods of achieving an accessible walkway for people with disabilities. Traditional construction practices for installing any sort of paved walk requires cutting into the existing grade to lay an aggregated base, intentional compaction of the existing soil beneath the base, another round of compaction with a steamroller to set the aggregate and then finally laying the asphalt. This method is obviously not acceptable within the protection zone. An easy alternative to the standard practice is a method in which the path is simply laid on top of the existing grade. Laying the path on top relieves the need to cut in to the existing grade in order to make the path flush with the ground. Other modifications to the standard practice. Geotextile placed beneath an aggregate base consisting of larger stones helps to dissipate almost all of the weight. A steamroller is still needed to lay the asphalt, but the geotextile and large aggregate distribute the weight so effectively that there is virtually no compaction of the soil below.

# **ALTERNATIVE PAVING DETAIL**



This form of alternative paving is not the only alternative. The challenge of creating a path that traverses the roots and causes little impact can inspire creative solutions. As part of the process of trying to solve the puzzle and arrive and the best solution for this particular situation it seemed necessary to explore several different design alternatives incorporating different devices.

The first design scheme to consider was the plan that had already been proposed by a landscape architecture firm. Evaluating the previously suggested scheme against the criteria for the path and the criteria for tree preservation served as a reference for what to do and/or what not to do in devising new alternatives.



The previous scheme deals with the criteria of the path beautifully. The path slopes down from the parking lot to the Widener building at the prescribed 5% slope, it catches people off the driveway inviting them to follow the new path and it incorporates a welcoming node at the start of the path and provides a space near the visitor center where visitors can gather to go on guided tours of the Arboretum. The criteria that this scheme does not satisfy are those which pertain to preserving the health of the Bender oak. The most obvious transgression is that the path is laid across the protection zone with no provisions for alternative paving methods. The proposed grading near the start of the path calls for significant cutting of grade within the protection zone, which could possibly damage or sever potential structural roots. Also some seemingly unnecessary construction work is proposed within the dripline of the tree to remove parts of the path and the needs of the tree.

#### **ALTERNATIVE SCHEME 1**



The first alternative scheme takes the safest route circumnavigating the entire protection zone. If this scheme were to take affect then a large fence could be erected around the protection zone preventing any activity to take place where roots could be damaged. This would be an ideal situation from a tree preservation standpoint, however this scheme is barely practical in regards to the criteria of the path. The path does not entice people off the road nor does it provide a welcome node. It takes such a round about route to the Visitors Center that few people would even know where it was going and even fewer people would ever walk on it. This scheme is on the opposite end of the spectrum from the previous. This illustrates that over-precautionary measures with regard to preserving tree health can sometimes be impractical. A compromise is needed.

## **ALTERNATIVE SCHEME 2**



The second alternative design scheme incorporates the alternative paving method in which the path is laid on top of existing grade. In order to implement this alternative method of paving all the areas where the alternative method is used grade change can only be facilitated with fill. Filling soil on top of roots can be harmful, but the impact of the fill is greatly lessened when the fill material is large aggregate. Using the tree-friendly paving allows the path to follow almost the same path as was proposed in the beginning. The major differences between this scheme and the original scheme are in the areas beneath the dripline of the tree where the path begins. The new path here is laid directly on top of the existing path. There is no need to disturb the soil to try to remove and reroute the existing path when the new path can simply be laid directly on top.

#### **ALTERNATIVE SCHEME 3**



The final alternative scheme solves the problem of balancing the needs of the path and the needs of the tree by adding a feature that highlights the tree and provides visitors with an opportunity to safely interact with it without endangering the health of the tree. This scheme uses a boardwalk elevated only a few inches off the ground to carry visitors over the delicate root system. This boardwalk approaches the tree and actually circles around the trunk allowing visitors to touch the tree and view it from different perspectives. By introducing an exciting, unique feature more people will be enticed to come off the road and on to the path. Highlighting the tree and visibly illustrating a tree preservation technique can also give the Arboretum an opportunity to educate visitors about tree preservation through interpretive signs. This proposal does not just address the needs of this particular tree; it adds a feature that could potentially save other trees by educating the public about tree conservation.

#### **CONCLUSION**

Educating people about preserving trees during construction is the most effective way to ensure that more trees are not needlessly lost. Many developers understand the value of trees and intend to preserve them during the construction process however they fail to do so because they are simply unaware of the correct procedures. The only way to prevent the carelessness that kills beloved trees is to show all those involved in the construction process the repercussions of their actions.

# **REFERENCES**

Campion, Dennis R. 1997 <u>Plant health Care For Woody Ornamentals.</u> International Society of Arboriculture. Champaign, IL

Harris, Richard W. 1992. <u>Arboriculture: Integrated Management of Landscape Trees, Shrubs and Vines.</u> Prentice Hall. Englewood Cliffs, NJ

Matheney, Nelda and Clark, James R. 1998. <u>Trees and Development: A Technical Guide to</u> <u>Preservation of Trees During Development.</u> International Society of Arboriculture. Hagerstown, IN

Pais, Richard at Ecoscientific Solutions (Personal Interview)

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