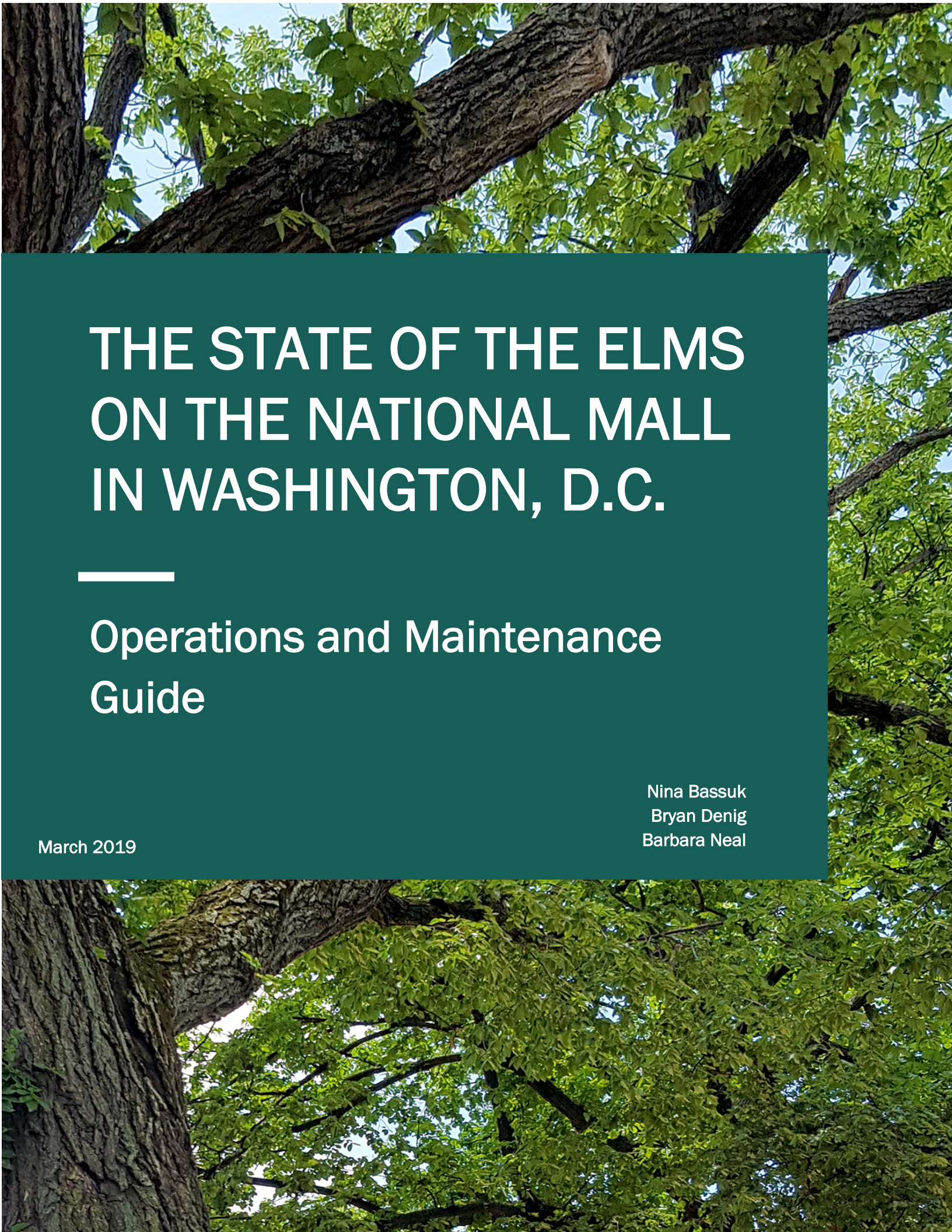

THE STATE OF THE ELMS ON THE NATIONAL MALL IN WASHINGTON, D.C.

Operations and Maintenance Guide

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INTRODUCTION

In the summer of 2017, a team of researchers and arborists from Cornell University's Urban Horticulture Institute evaluated the condition of the elms and soils on the National Mall in Washington DC. A report on the findings of that work was completed in spring 2018 and presented to the National Park Service. A copy of that report is available from the Urban Horticulture Institute's website:
http://www.hort.cornell.edu/uhi/research/articles/National%20Mall%20Elms_2018.04.07.pdf.

Based on those findings, and in accordance with recognized best practices in arboriculture and urban soil science, this Operations and Maintenance Guide was produced. Its recommendations are described in the following twelve sections:

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Recommendation #1—Have an on-staff arborist or contract with a consulting arborist

When the Cornell team met to present our findings to the National Mall elms stakeholders, the National Capital Area Park Service staff reported that they did not have an arborist on staff, nor were they certain that the position would be filled going forward. Filling that position would go a long way in meeting the planning and monitoring needs of the National Mall elms. However, if it is not possible to fill that position, the Cornell team strongly recommends that the National Park Service hire a consulting arborist who would work on a schedule and be available on an as-needed basis. A consulting arborist would regularly inspect, scout, and make detailed work task recommendations for the trees on the National Mall. Having a consulting arborist on hand would help ensure that the trees receive thoughtful, timely, and cost-effective treatments. It is a cost-effective way to get a high level of arboricultural expertise without committing to a full-time staff person.

Few in the general public are aware of the role of a consulting arborist—they assume that all arborists work for tree care companies. A consulting arborist differs from an arborist practitioner in that he or she typically is not allied with a tree care company and has a fiduciary relationship with his or her clients. That is, the burden is on the consulting arborist to put their clients' needs first. There are some consulting arborists who are representatives of a tree care company, but they often will recuse their company from bidding on the work that they recommend to avoid having any appearance of a conflict of interest.

The consulting arborist should be a Registered member of the American Society of Consulting Arborists (ASCA, https://www.asca-consultants.org/default.aspx). The Registered Consulting Arborist should be familiar with working with urban trees, municipalities or other governmental organizations, and the Mid-Atlantic environment.

In addition, the consulting arborist should be a Board Certified Master Arborist or a Certified Arborist with the International Society of Arboriculture (ISA, http://www.isa-arbor.com/). Virtually all consulting arborists hold one of these two designations, and the Board Certified Master Arborist is the preferred qualification.

Finally, an additional preferred credential would be a consulting arborist who has documented experience in tree risk assessment. Many consulting arborists hold the Tree Risk Assessment Qualification, which is administered by the International Society of Arboriculture (http://www.isa-arbor.com/Credentials/ISA-Tree-Risk-Assessment-Qualification). These arborists have demonstrated proficiency in visual tree risk assessment.

Recommendations

- *The trees on the National Mall should be scouted by the staff or consulting arborist at least three times per year.*
- *The staff or consulting arborist should approve the purchase of replacement trees for the National Mall.*

The first scouting survey should be done in the winter in order to plan and schedule late winter pruning of the trees. The arborist will note which trees require pruning, prioritize the pruning, and give guidance as to proper pruning techniques.

The second scouting would be done in the late spring. The purpose of this visit is two-fold: to scout for flagging branches that indicate Dutch elm disease and to make specific recommendations for tree protection fencing and tree protection measures to protect those trees at risk of damage due to public events such as the Smithsonian Folklife Festival. The arborist would meet with the Smithsonian Folklife staff to understand the scope of the festival and work with the Smithsonian staff and NPS staff to design tree protection measures. The arborist would also determine which trees, if any, should be treated with fungicide.

The final visit would be in the early fall. The arborist would assess those trees identified as higher risk and make recommendations for pruning, cabling, or removal.

The Cornell team estimates that each visit would require two to three days on-site and one day for reporting/creating work orders/managing the database.

In addition to these three scouting visits, the consulting arborist should inspect replacement trees for suitability on the National Mall prior to acceptance and planting. This could be done by reviewing photographs of the young tree or direct inspection at the nursery. The staff or consulting arborist should also be available for as needed consultations—whether on-site or virtually. The total estimated number of days a consulting arborist would be needed each year is approximately 17 to 20 days. The following is the annual scope of work for the staff or consulting arborist:

1. Three site visits per year (winter, late spring, fall), with a complete reporting of findings and development of detailed maintenance work orders
2. Approximately ten ISA Level 3 assessments of trees that need a more intensive risk assessment per year
3. Developing a tree preservation plan for the Smithsonian Folklife Festival
4. Inspecting (on-site or virtually) replacement trees in the nursery
5. Ongoing planning and management of maintenance tasks for the trees on the National Mall
6. Maintaining a tree software management system
7. Every three years conduct a complete ISA Level 2 Basic Tree Risk Assessment of all the trees on the National Mall
8. Assist the National Park Service in determining a budget for annual tree maintenance
9. Assist the National Park Service in evaluating large scale event permit requests
10. Provide face-to-face and hands-on training in the latest tree care industry standards of care to NPS tree care staff.

The Cornell team believes that having a highly trained arborist to guide the annual work cycle of the tree maintenance on the National Mall is the single best management step that the National Park Service could take. Investing in a long-term relationship with a consulting arborist would save money in the long run and would result in trees that are healthier and more aesthetically pleasing.

Recommendation # 2—Use a tree management software system

The Cornell team recommends that the National Park Service purchase or subscribe to a tree management system to manage the trees on the National Mall. There are several worthy tree management software packages that professionals use to manage the day-to-day tasks and overall health for a group of trees. These tree management software systems allow users to upload an existing inventory of trees into the system, and then write work orders and track work events such as pruning, removal, and replanting with relative ease. Ideally, the tree management software system would be kept up-to-date by both the NPS tree crew as well as the staff or consulting arborist. The staff arborist or consulting arborist may have familiarity with one system over another, so that might play a factor in deciding which system to invest in. The arborist would use the system to plan maintenance tasks and write work orders. NPS tree crew leaders would be trained in the software so that they can note which trees were worked on and when. Purchase records and provenance could be tracked when a young tree is planted on the National Mall.

The tree management software should have the following capabilities:

1. Bulk upload of existing tree inventory data
2. Ability to track new inventory data to compare growth/mortality/tree risk, etc.
3. Ability to create work orders, track their progress, and assign crews. It would be helpful to be able to attach a picture of a tree issue to a work order as well as to print a map showing all the trees involved in the work order
4. Ability to create lists of trees of concern for special monitoring (e.g. trees deemed at high risk, trees that get Dutch elm treatment, newly planted trees)
5. New trees will have purchase information such as nursery provenance, cultivar, size, etc.

An excellent discussion on preferred urban forestry management software capabilities is *Data Management for Urban Tree Monitoring – Software Requirements (2016)*, prepared by Azavea for the Pennsylvania Horticultural Society and the USDA Forest Service. The document compares leading software programs and details their differences. While the document is specifically oriented to tree management as well as fostering citizen science data collection, the appendix in the back provides useful information.

A final key criterion for determining a program's suitability is the sustainability of the software. There are several programs that were developed by smaller companies, and, while they may be of excellent quality, it is possible that they may not be able to support upgrades well into the future. The Cornell team recommends that the National Park Service purchase software from a company with a long track record, a knowledge about trees and arboriculture, and strong financial footing so that the software will be useful for many years to come. A few of these programs include: ArborPro (http://arborprousa.com/), ArborScope (https://www.bartlett.com/), TreeKeeper (http://www.davey.com/environmental-consulting-services/urban-forestry-consulting/tree-inventory-management/tree-keeper/), and Tree Plotter (https://treeplotter.com/) .

Recommendation

The National Park Service should purchase a tree management software system that produces useful reports, can create and track work orders, can accommodate updates to the inventory, and will be kept viable for years to come.

Recommendation #3—Develop and fund a budget so that work can be scheduled and completed in a timely manner

The Cornell team recognizes that governmental agencies and municipalities struggle with limited funding. We recommend that an annual budget be developed and funded so that the trees on the National Mall can be adequately cared for in a timely manner. For example, the budget would include consulting fees if a consulting arborist is retained, and monies for the prompt removal of branches that are infected with Dutch elm disease, fungicide applications, and the purchase and installation of high-quality new trees. Some maintenance items are costly to do (say, re-cable a tree) but will not have to be redone for twenty years or so. Other maintenance items, such as replacing dead trees and pruning deadwood, are annual work tasks. Some work tasks are high priority (for example, removing a large lateral branch that is at high risk of failure), while others are less so (inspecting cables). The budget should allow for quick turnaround from identification of a high priority issue/task to completion of that task.

As our weather continues to intensify, we can expect severe storm events to occur more frequently. The budget should include monies for storm cleanup. For many storm events, there are necessary clean up tasks that must be done within a short period of time. The budget should include the ability to quickly assess and mobilize pruning crews following a storm to mitigate the damage and risk.

The Cornell team identified many potential maintenance tasks that should be done for the elms on the National Mall. Getting a cost to complete those tasks will give the National Park Service an idea of the budget level necessary to maintain the trees. The staff or consulting arborist should be able to help the National Park Service develop an annual budget for maintaining the trees on the National Mall.

Recommendation

The National Park Service should have a dedicated annual budget for tree care on the National Mall that includes line items for regular maintenance, consulting fees, annual planting, and a contingency fund for emergency work.

Recommendation #4—Follow a management calendar for timely pest scouting and treatment, planning for tree replacement and pruning, and other tree-related tasks

Calendar of Management Tasks:

All year

- Removal of limbs or trees with Dutch elm disease— removal/pruning to be done within 30 days of disease diagnosis

Winter (December through February)

- Arborist scouts the trees for pruning and cabling needs
- Arborist determines which trees will be replaced and trees are ordered from a reputable nursery to be dug during tree dormancy for late fall planting
- Structural pruning of young trees. Structural pruning starts one year after planting and continues to five years after planting. Each new tree to be pruned at least every other year for three pruning cycles.
- Crew removes deadwood from large trees and removes trees if deemed necessary by the arborist.
- Crew repairs or replaces cables as determined by the arborist
- Crew mulches young trees to maintain mulch ring. Existing mulch to be scarified prior to reapplication. Any rodent burrows should be noted and appropriately treated if deemed necessary.

Early Spring (March through April)

- No pruning is done at this time, while beetles are active (starting in late March/early April) and leaves are expanding

Late Spring (May through June)

- Arborist monitors trees for signs of Dutch elm disease and verticillium. Arborist determines which trees receive fungicide treatment
- Arborist plans for the tree preservation fencing for the Smithsonian Folk Life Festival
- Crew installs tree protection fencing and mulch for soil compaction resistance as needed to impacted areas as per the arborist's plan

Summer (July through early September)

- Monitor trees for signs of Dutch elm disease, elm yellows and verticillium
- Treat mature trees that show signs of Dutch Elm Disease with fungicide such as Arbotect 20-S, Arborjet with Propizol, or Alamo after the diseased limbs have been removed to limit the spread of the disease.

- Trees that exhibit signs of Elm Yellows should be removed as soon as possible and disposed of off-site.
- Monitor trees for drought stress
- Water young trees (planted the year prior) using 20 gallon drip water bags. Bags should be filled at least once per week if there is not a significant rainfall event (more than ¼") the week prior
- Begin soil remediation for planting areas in September

Fall (mid-September through November)

- Tree Risk Assessment of mature trees and scout for girdling roots on juvenile trees
- Complete soil remediation for planting areas
- Plant replacement trees
- Post-planting management, such as watering, fencing, etc.
- Crew removes support systems such as stakes and guy wires from trees that were planted the prior year

Recommendation #5—Conduct regular tree risk assessments of the trees on the National Mall

In the summer of 2017,the Cornell team conducted a complete inventory of the National Mall elms, which included an ISA Level 2 Basic Visual Tree Risk Assessment for each tree. Most of the trees posed low risk to the public, and the trees that we felt were high risk were identified to the National Park Service at the conclusion of the inventory process. Of course, there were trees that had defects that should be addressed but were not considered a high risk at the time. The maintenance needs for these trees should be addressed in the near future. Some require a new cable or cables to be installed, while others require deadwood pruning. Our inventory documented what we felt was the priority level for each tree. Typically, the higher risk trees are addressed first, followed by the medium and lower risk trees.

Tree risk assessments are only valid for a short time— typically less than three years. Given the high visibility of the site and the large numbers of pedestrians, the Cornell team recommends that the staff or consulting arborist evaluate any tree deemed a high risk annually, and all trees should be evaluated at least once every three years. The Cornell team believes that the ISA Level 2 Basic Visual Tree Risk Assessment is the proper level of scrutiny for the trees on the National Mall, unless the staff or consulting arborist determines that a more intensive Level 3 Tree Risk Assessment is warranted for individual trees.

An ISA Level 2 Basic Tree Risk Assessment cannot guarantee that all trees that pose a potential threat to public safety are noted by the visual inspection— significant decay can be present in a tree's roots, trunk or branches and not present outward signs or symptoms that would alert the tree risk assessor. However, a Level 2 Basic Tree Risk Assessment is considered a reasonable risk management technique for agencies and companies that manage public trees.

Recommendations

- *Every three years— We recommend that the National Park Service have a staff arborist or consulting arborist conduct a complete Level 2 tree risk assessment for the trees on the National Mall.*
- *Every year— We recommend that the arborist evaluate those trees that the Cornell team identified as having a high risk rating.*
- *The National Park Service budget should include a line item for more intensive Level 3 Tree Risk Assessment for trees that require a more extensive risk assessment*

For some trees, the arborist will request a Level 3 tree risk assessment. Level 3 tree risk assessments will include additional investigative techniques such as root collar excavation, decay testing, or aerial inspection. The Level 3 assessment gives a more complete picture of the risk posed by a tree— but it is much more time consuming and costly to conduct. A Level 3 assessment is typically only recommended when an arborist has significant concerns about a tree and the risk it poses to the general public or infrastructure. The NPS should have a budget line item that allows for approximately ten Level 3 assessments per year for the first three years, and then for five Level 3 assessments in following years.

The consulting arborist should adhere to the most recent version of the *ANSI A300 (Part 9) American National Standard for Tree Care Operations - Tree, Shrub, and Other Woody Plant Management - Standard Practices (Tree Risk Assessment a. Tree Structure Assessment) 2017,* as well as the best management practices as outlined in the International Society of Arboriculture's *Best Management Practices: Tree Risk Assessment, Second Edition.*

Recommendation #6—Build tree and soil protection into permits for large-scale events

Much effort is put into the National Mall elms to keep them healthy and thriving. One of the greatest threats to the trees' long-term health is the level of soil compaction in the panels. The Cornell team documented high levels of soil compaction throughout the National Mall.

Unfortunately, soil structure, the aggregation of soil particles that allows for drainage and aeration as well as healthy root growth, is easily damaged and is not easily repaired. Vehicular traffic, heavy pedestrian use, and the like can crush the soil particles and make the soil too dense for root growth to occur. Preserving soil structure is a key component of maintaining a healthy stand of trees.

The Cornell team recommends that the National Park Service integrate tree protection measures into its large-event permitting process, much like it does for the turf areas. The staff or consulting arborist would work with large-scale events, such as the Smithsonian Folklife Festival, to develop a tree and soil preservation plan, and then monitor the compliance for the National Park Service.

Soil compaction is the greatest challenge to the long-term health and viability of the trees on the National Mall. Given that the space is intensively used by the general public, some amount of pedestrian foot traffic compaction is bound to occur. Large events such as the Smithsonian Folklife Festival are a signature feature of the National Mall, but they do pose a risk to the trees. The Folklife Festival is located in a different portion of the Mall each year, which helps to avoid repeated construction and pedestrian related soil compaction, but steps can be taken each year to minimize and mitigate soil compaction so that the trees surrounding the festival are not unduly damaged.

Recommendations

- *The staff or consulting arborist should develop a tree preservation plan for each summer's Smithsonian Folklife Festival and all other large-scale events that take place on the National Mall's tree panels.*
- *If at all possible, for large-scale events such as presidential inaugurations or marches, fencing should be used to keep people and equipment out of the tree growing panels.*
- *If people or materials are expected to be on site, critical tree and soil protection zones should equal 1.0' for every inch of DBH, i.e. a 15" DBH tree should be protected by fencing in a radius of 15' around the tree. It should be made of sturdy fencing such as wood panels, chain link or similar. These protection fences should be easily placed and removed and be reusable. Where the tree and soil protection zones overlap with nearby trees, protection fencing should encompass the groups of trees and not each individual tree. Any areas where the soil has been remediated using the "Scoop and Dump" technique described in Recommendation 8 should be entirely contained within fenced protection zones in order to preserve the improved soil conditions.*
- *There may be instances where construction or materials need to be used within the critical tree and soil protection zone. In this case a smaller 'no impact zone' of 10'*

away from tree can be used. No construction or storage of materials should be allowed within this zone.

- *When large numbers of pedestrians are expected or construction of temporary stages are to be placed into the tree panels, a 6"-8" thick layer of coarse mulch or woodchips should cover the soil on site and remain until the event is finished.*
- *The wood chips should be removed and only a radius of mulch 6' around the tree should remain after the festival and infrastructure breakdown is complete (see Recommendation 9).*
- *Special care should be taken to fence off young trees (<6"DBH) that may be physically imperiled by masses of people. Fencing of young trees should be no less than 8' square.*
- *Tree preservation plans should take particular care of signature trees (trees rated Excellent in the Cornell team's assessment). They should have a critical root zone that equals a 2' radius for every inch of DBH i.e. a 20" DBH tree should have a 40' radius of tree protection.*
- *Permits to hold events on the National Mall should include tree preservation provisions and inspections as is done for the turf panels. At least 3 years should elapse before a high-impact event such as the Smithsonian Folklife Festival is held on a group of tree panels.*
- *Every effort should be made to communicate the tree preservation plan's specifications to all event staff and event subcontractors, and an NPS staff person should be tasked with oversight of compliance with the tree preservation plan and implementation.*

Tree preservation techniques are not expensive nor difficult to install. Installation of protective fencing is already a well-established practice on the National Mall and goes a long way towards limiting soil compaction. Using a thick layer of woodchip mulch (at least 6") to protect the soil during events is also an inexpensive and effective way to protect the soil. Physical barriers that protect tree trunks are likewise easy to install.

Despite the relatively low cost of tree preservation, it is important that each large-scale event have a tree preservation plan in place. Decisions that seem small, such as the location of roll-off containers (dumpsters) for trash, can have outsized effects on the trees. Tree preservation plans require a knowledgeable arborist working with the event's organizers to come up with a plan that is easy on the trees and easy to install and implement for the event's staff.

The staff or consulting arborist should draw up tree preservation plans in accordance with the latest industry standards. The most recent version of the ANSI A300 Part 5 *Management of trees and shrubs during site planning, site development, and construction* should be used, as well as the best management practices as outlined in *Best Management Practices During Construction* published by the International Society of Arboriculture.

A tree preservation plan is only useful if there is proper oversight of the installation of the tree preservation techniques and if all members of the installation crew are aware of the tree preservation goals and techniques and adhere to the plan. Once a plan is developed, every effort

should be made to communicate the plan to the event staff, the subcontractors for the event, and NPS tree care staff. The old adage “the devil is in the details” is a truism when it comes to tree preservation. One careless contractor can irreparably harm a mature tree. We recommend that an NPS staff member be tasked with ensuring the proper tree preservation techniques be installed prior to commencing construction and performing periodic inspections during the event and its disassembly.

Recommendation #7—Consider increasing the tree species diversity on the National Mall

The Cornell team recognizes the long history and association of the American elm (*Ulmus americana*) on the National Mall. Making the recommendation to use trees that are not this species for replacement plantings is understandably controversial. Since its conception, the National Mall has been defined by its orderly ranks of American elm trees. As stated by Frederick Law Olmsted Jr. in a 1932 letter, "It was considered therefore, at the beginning, that the similarity of these trees, their high canopy of foliage and the gothic arch effect of their branching were all essential parts of the design."[1] Understandably, when trees on the Mall have needed to be replaced over the years, the replacement trees have almost always been *Ulmus americana*.

Unfortunately, the appeal of continuing to plant only American elms as replacement trees is outweighed by its disadvantages. The monoculture planting is highly vulnerable to total loss due to a single pest or pathogen, and the management strategy of replacing dead and declining trees with young American elms, albeit selections that are resistant to Dutch elm disease, may be short-sighted given the threat of other pathogens such as Elm Yellows. Losing all the trees on the Mall over the course of a few years, which is a very real possibility should Elm Yellows strike the National Mall, would have devastating maintenance and psychological impacts. By diversifying the tree species that compose the National Mall landscape, the risk of this kind of catastrophic loss would be reduced.

While the Cornell team is concerned about the continuing toll that Dutch elm disease (DED) is exacting on the Mall landscape, we are even more worried about the threat of Elm Yellows. While planting DED-resistant American elms reduces the potential impact of that disease, there are currently no American elms that are resistant to Elm Yellows. This disease, also known as Elm Phloem Necrosis, could potentially result in the complete loss of the trees on the National Mall over the course of a few years. There is currently no treatment for Elm Yellows, and little can be done to prevent it. The best method for limiting the potential impact is by planting tree species that are not susceptible.

To reduce the impacts of potential pests and diseases, current best practices for managed tree populations include conscious species diversification within a management area. For an urban forest, one rule of thumb is to not have more than 10% of one species, 20% of one genus, and 30% of one family—and many urban forest managers strive for even more diversification than that. This is very different from the National Mall tree population, which is essentially 100% one species.

As a cultural landscape, the National Mall must be managed with careful consideration given to preserving its historical integrity, and it would be inappropriate to plant trees that are incompatible with its character. While some may argue that planting any tree other than *Ulmus americana* on the National Mall is inappropriate, landscape preservation objectives must be balanced against the

[1] see 2006 Cultural Landscape Inventory

practical need for species diversity. Other tree species can still be compatible with the aesthetic character of the Mall and would be appropriate choices for replacement plantings.

It is important to note that the original design intent of having perfectly matched trees with high canopies creating a gothic arch effect on the Mall was never fully realized. While originally intended to be a landscape composed solely of vase-shaped American elms, this landscape has historically always been composed of American elms with diverse growth habits. Variations in tree habit and form were noted soon after the initial plantings, as documented in a 1945 report on the young landscape.[2] Also, after decades of replacement plantings, the trees growing on the Mall today represent a large range of ages and sizes. Trying to create the level of visual uniformity initially intended by the original design today would require clear-cutting the Mall and replanting with trees of the same age and growth habit.

We believe that diversifying the tree species in the National Mall planting is crucial for its resilience. We also believe that it is possible to have greater tree species diversification without sacrificing visual uniformity. In fact, through careful selection of replacement tree species, and with rigorous structural pruning of young trees to achieve a high-canopy form, the trees composing the National Mall could become more aesthetically uniform than they are currently, while still being composed of a greater diversity of species.

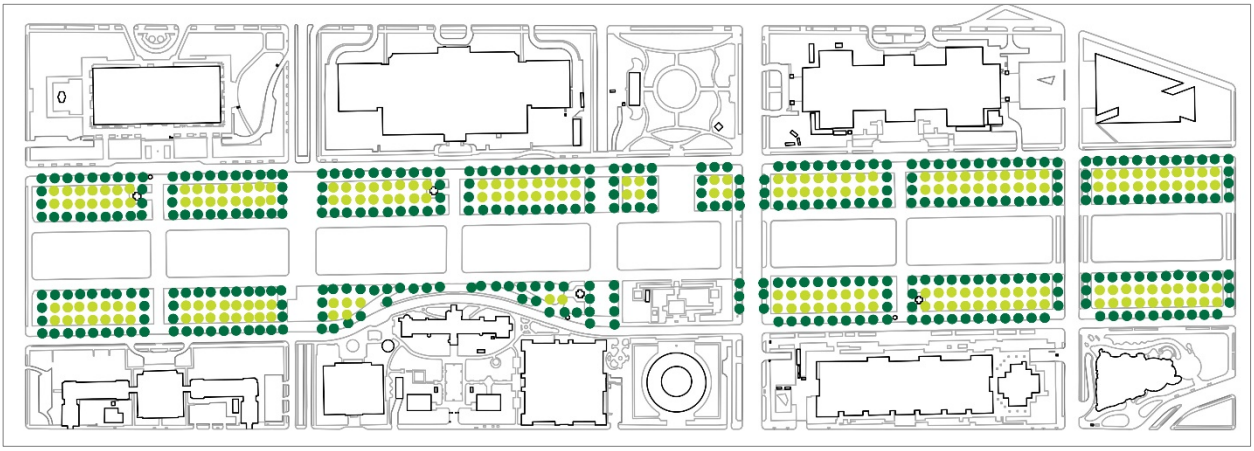
While it is easy to see the differences in size and form when comparing individual trees to one another, when viewed as a whole, the trees on the National Mall create a fairly uniform planting. Looking down the axial vista, from the Capitol to the Washington Monument, the tree canopies framing the view on either side blend together into a continuous undulating mass, and the differences between individual trees become less discernable. There are a few notable exceptions: trees of the 'Augustine Ascending' cultivar are distinctly different than the other American elms. These trees have a tight, upright form, and are especially noticeable because they grow much taller than the others. Because of these unique visual characteristics that make it stand out from the crowd, this cultivar of American elm is considered inappropriate for this historic landscape.

[2]see 2006 Cultural Landscape Inventory

Even though essentially all the trees on the National Mall are the same species, they vary greatly in growth habits. A mature 'Augustine Ascending' tree (left) is especially discernable in this group.

Although the tree sizes and growth habits vary, their individual differences are less noticeable while looking down the main axis of the Mall

Achieving visual uniformity of trees in a landscape is not only accomplished through exclusive use of a single species. Other tree species can still be compatible with the aesthetic character of the National Mall and would be appropriate choices for replacement plantings. Through careful selection of tree species and cultivars that possess visual qualities similar to the classic vase-shaped American elm, we believe it is possible to increase species diversity without detracting from aesthetics. Also, as the current planting is composed of many diverse forms of one species, we believe that the careful incorporation of other aesthetically appropriate tree selections could potentially result in a more visually uniform planting than what currently exists.



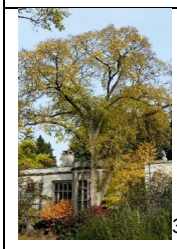
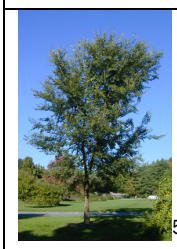
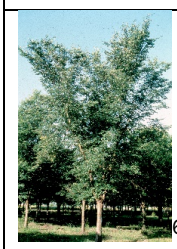
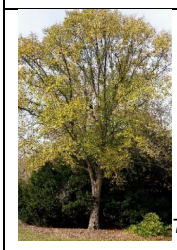
Dark green circles represent the "outer," highly visible trees. These must look like the classic vase-shaped American elm. Light green circles represent the "inner," less visible trees. These may deviate slightly from the classic vase-shaped American elm ideal.

Tree species and cultivars that are appropriate for replacement plantings on the National Mall must resemble the classic vase-shaped American elm. They must be large growing trees with appropriate mature height and spread dimensions and have vase-shaped canopies with fine-textured foliage. Because of the grid design, some trees on the Mall contribute more to the aesthetic character of the landscape than others. The trees lining the outer edges of the panels are much more visible than the inner trees, so they have a greater role in defining the character of the landscape. These differences in visual prominence have led us to consider potential replacement trees as belonging to two distinct groups:

Group A trees are extremely similar to the classic vase-shaped American elm and are recommended for the highly visible "outer" locations. This group is composed of other elm species and hybrids that have the desired growth habit and are highly resistant to Dutch elm disease and Elm Yellows. Following the devastation of the American elms to Dutch elm disease, multiple efforts sought to develop other elm species to create disease-resistant alternatives that still had the beautiful vase-shaped form. Many of the trees in Group A are the direct results of those efforts. Most people would be unable to distinguish these trees from *Ulmus americana*.

Group B includes non-elm trees that are similar to American elms visually, but less so than the trees in Group A. These trees are not recommended for the highly visible outer row locations, where their differences from the American elm ideal may be noticeable. However, these trees would be good choices for replacement plantings in the less prominent inner row locations. Thoughtful selection and care would help these trees blend in with the surrounding elms. For example, zelkova trees tend to have their branches start relatively low on their trunks. Careful structural pruning to raise the crown of these trees would help maintain visual uniformity. Also, in the nursery trade hardy rubber tree is produced from seed, and the resulting genetic variability means that some of these trees may have undesirable growth habits. The trees to be planted on the Mall should all be carefully selected from the nursery to ensure that their form meets the requirements.

This report includes lists of potential replacement trees species for these two planting groups, along with sketches that illustrate the mature form of these recommended trees. Understandably, there may be resistance to planting any trees on the Mall that are not *Ulmus americana.* A simple trialing program, for example planting a few of each of the listed trees on the Mall and assessing their performance and visual appropriateness for several years, could be a useful strategy for evaluating the suitability of these recommendations. It would also help demonstrate that the National Mall could have a visually uniform tree planting without being a monoculture.

GROUP A: Trees that are very similar to the classic vase-shaped American elm				
Photo	Common Name	Botanical Name	Mature Height	Mature Spread
 [3]	Accolade™ Elm	*Ulmus japonica* × *wilsoniana* 'Morton'	70'	60'
 [4]	Commendation™ Elm	*Ulmus* 'Morton Stalwart'	60'	50'
 [5]	Danada Charm™ Elm	*Ulmus japonica* x *wilsoniana* 'Morton Red Tip'	70'	60'
 [6]	Patriot Elm	*Ulmus* 'Patriot'	50'	40'
 [7]	Triumph™ Elm	*Ulmus* 'Morton Glossy'	55'	45'

[3] Bryan R. Denig

[4] Bruce Marlin [CC BY 3.0 (https://creativecommons.org/licenses/by/3.0)], from Wikimedia Commons

[5] Nina L. Bassuk

[6] USDA National Arboretum

[7] Bryan R. Denig

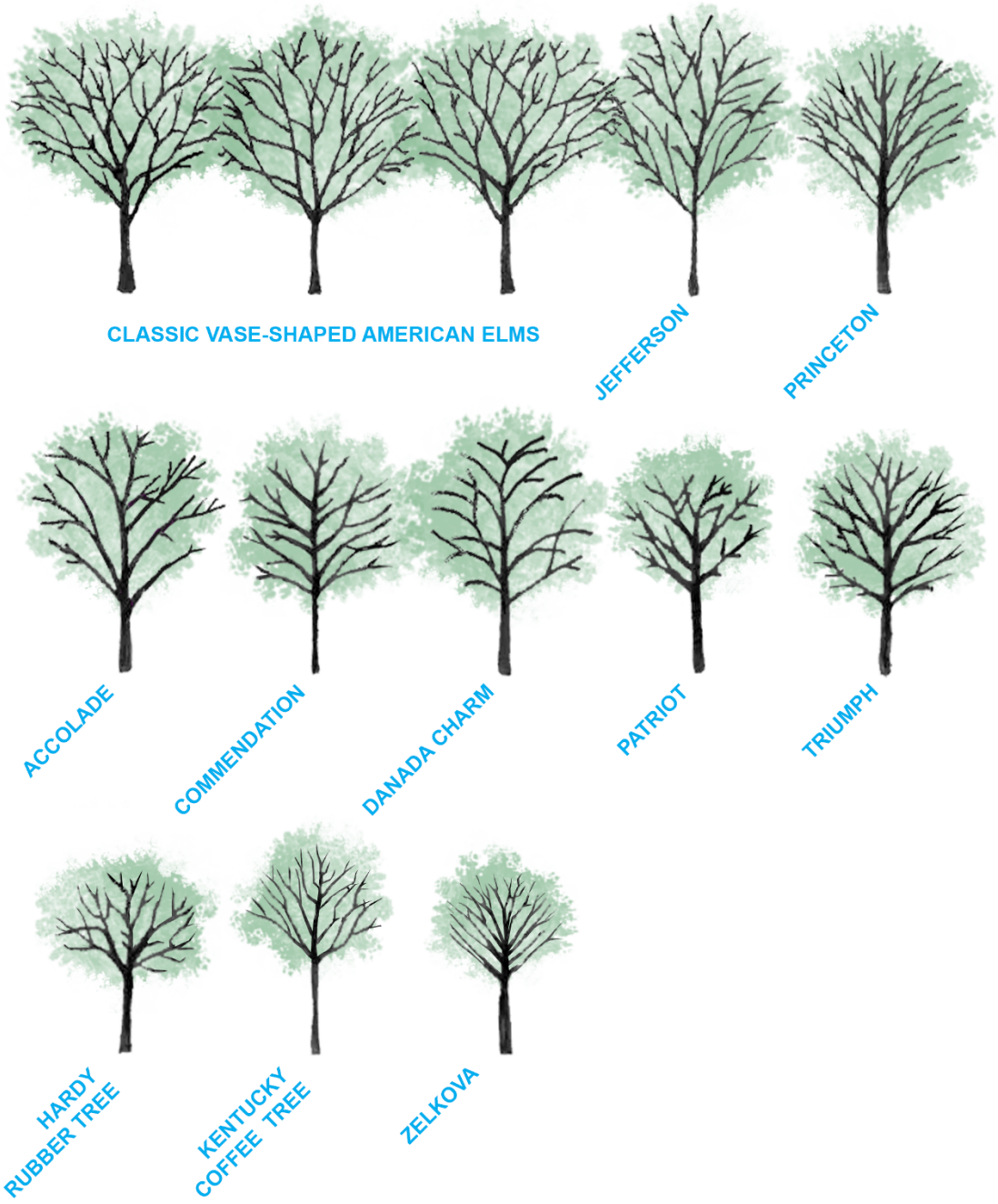
GROUP B: Trees that are similar to the classic vase-shaped American elm				
Photo	Common Name	Botanical Name	Mature Height	Mature Spread
 [8]	Hardy Rubber Tree	*Eucommia ulmoides*	45'	45'
 [9]	Espresso™ Kentucky Coffee Tree	*Gymnocladus dioicus* 'Espresso-JFS'	50'	35'
 [10]	Green Vase® Zelkova	*Zelkova serrata* 'Green Vase'	45'	30'

[8] Photo by David J. Stang [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)], via Wikimedia Commons

[9] Bostonian13 [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], from Wikimedia Commons

[10] Cornell Woody Plants Database

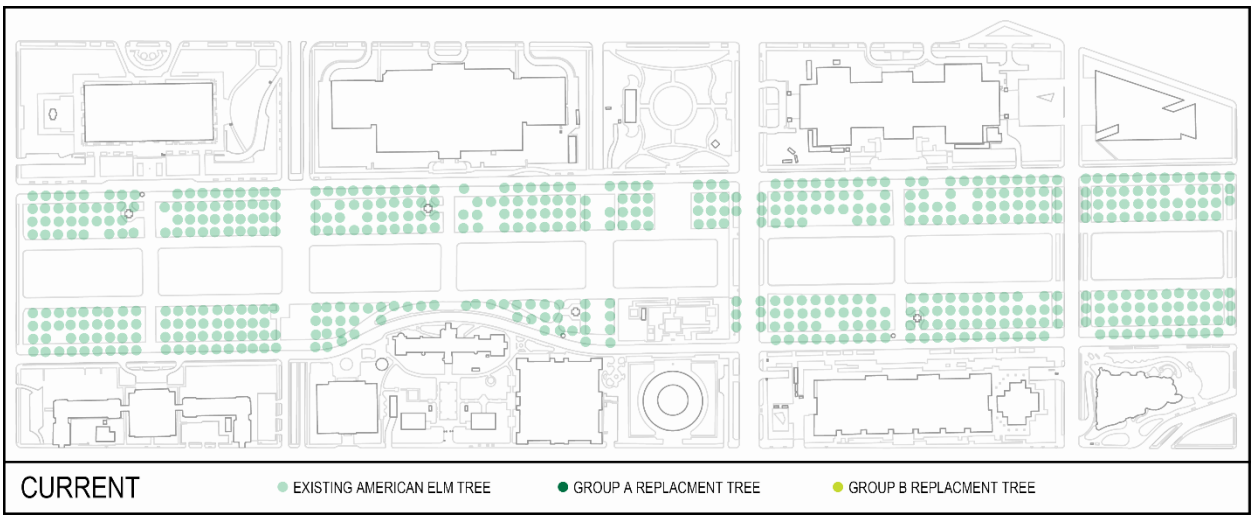
COMPARISONS OF MATURE TREE FORM



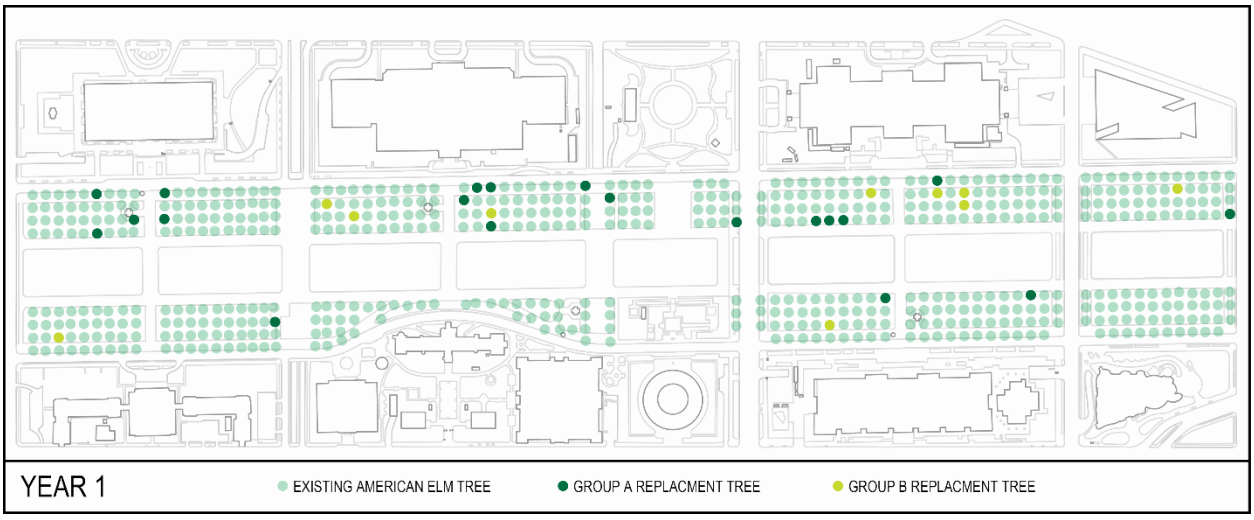
INTEGRATING OTHER TREE SPECIES INTO THE NATIONAL MALL

Each year, multiple trees on the National Mall are removed because of death (often due to Dutch elm disease), decline, safety concerns, or other reasons. Currently, the removed trees are being replaced with American elms. Using alternative tree species for these replacement plantings would increase the diversity on the Mall and support a more resilient landscape.

The following diagrams provide a theoretical illustration of how the tree population of the National Mall could be diversified over the next 20 years by planting trees other than American elms. These graphics are only meant to illustrate a concept, and they are not meant to suggest which individual trees need replacing.

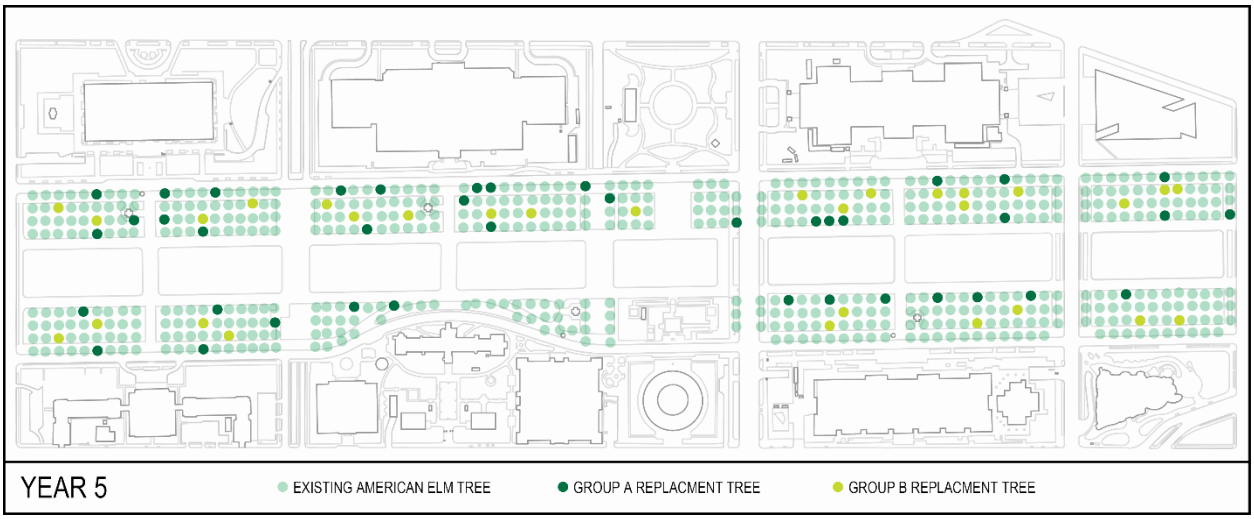


When we inventoried the trees in June 2017, essentially 100% of the trees were American elms. We also recorded approximately 30 potential planting sites (empty spaces in the grid).



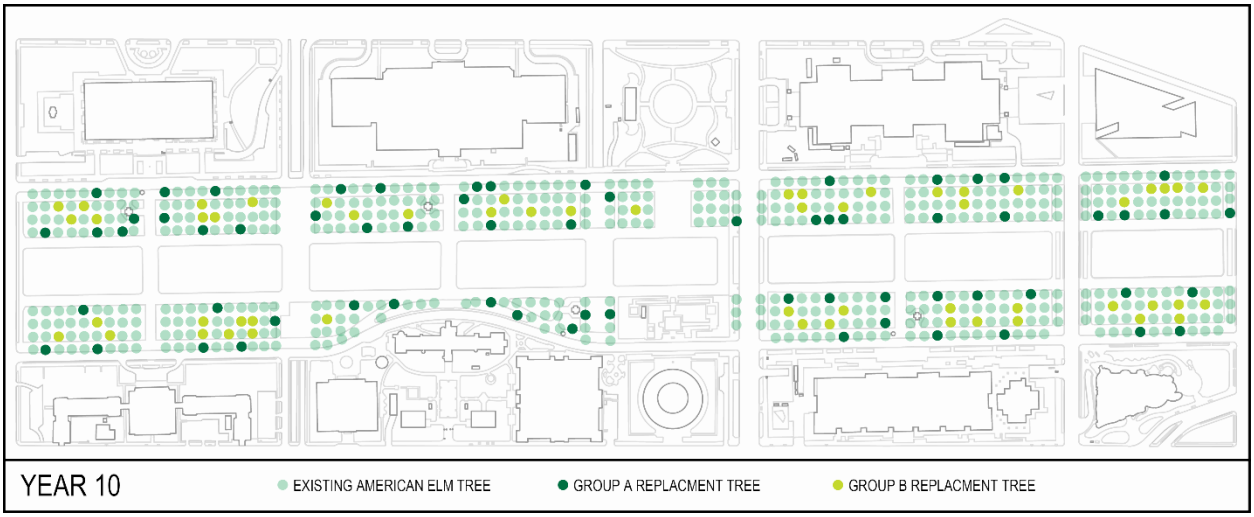
Planting trees in the 30 open spaces would start adding diversity in the first year:

95% American elm *3% Group A trees* *2% Group B trees*



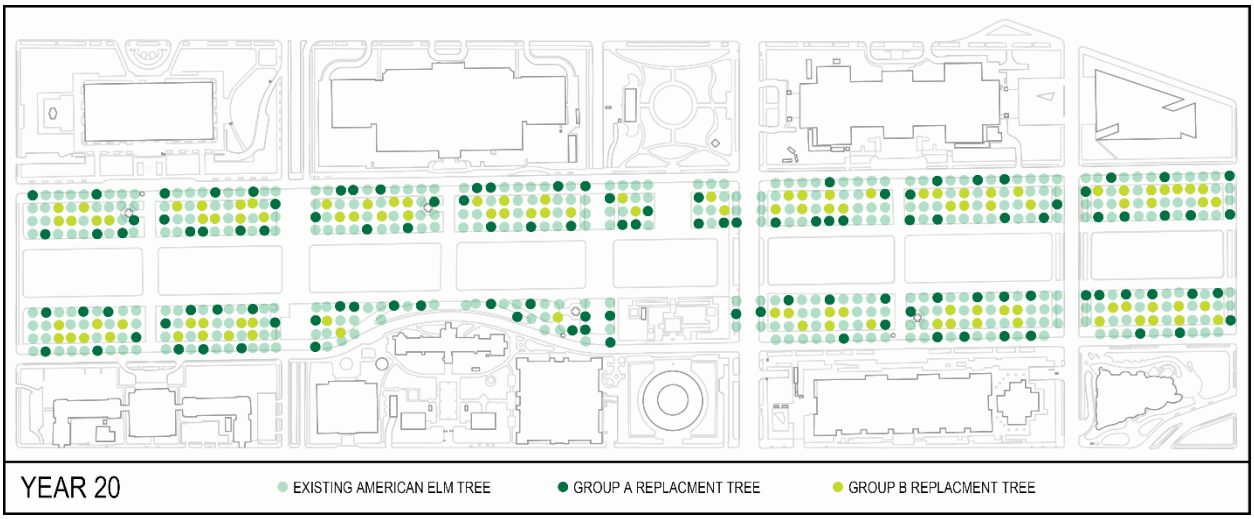
After the initial planting to fill the gaps, if we assume that 10 trees are replaced each year the population slowly continues to diversify. At year 5:

88% American elm *7% Group A trees* *5% Group B trees*



Continuing to assume that 10 trees are being replaced each year, at year 10:

79% American elm *11% Group A trees* *9% Group B trees*



Continuing to assume that 10 trees are being replaced each year, at year 20:

62% American elm *20% Group A trees* *18% Group B trees*

While this theoretical year 20 tree population does not meet the common urban forestry guideline of no more than 10% of one species, 20% of one genus, and 30% of one family, its increased diversity means that the landscape has increased resilience to devastating pests and pathogens. For example, if elm yellows were to decimate all the American elms in this theoretical year 20 population, at least 38% of the trees would be left standing.

Recommendation #8—Undertake a robust annual planting effort to replace dead and declining trees

Whenever trees on the National Mall are removed due to death, decline, safety concerns, or other reasons, new trees should be planted to take their place in the landscape. The grid configuration of the trees makes it easy to identify the vacant planting spots. During our tree inventory, the Cornell team recorded approximately 30 empty spaces in the grid, although it is possible that some of these locations are not suitable for replanting due to conflicts with underground utilities.

Ideally, the National Mall landscape would have a 100% tree stocking rate, meaning every planting space in the grid would have a tree. To achieve this goal, trees need to be planted in the currently vacant spots, and whenever an existing tree is removed in the future, it should be replaced with a new tree in the same location. After the initial planting to fill in the gaps, an annual effort to replace the trees that were removed the prior year will ensure that the National Mall is always fully stocked. As demonstrated in the previous section, a robust tree planting program could also be used to increase the species diversity of the trees on the National Mall.

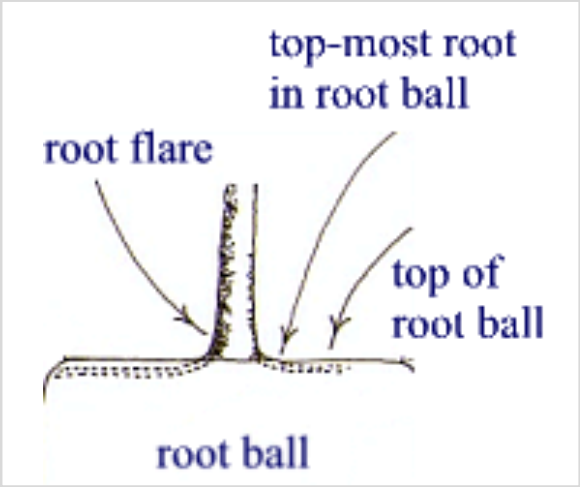
SELECTING TREES FOR PLANTING

All trees selected to be planted on the National Mall should be reviewed by the staff or consulting arborist for suitability prior to acceptance and planting. This could be done by reviewing photographs of the young trees or direct inspection at the nursery. Besides simply looking for high-quality trees free from defects, the arborist also needs to visualize how each tree will grow and mature after transplanting. They need to understand that most of the branches currently present on the young trees are merely temporary and will need to be gradually removed in the years following planting. Eventually, the mature tree should have a clear trunk for approximately 20'- 30' before the first permanent branch. A policy that all new trees will be gradually pruned to establish their lowest permanent branch at a consistent height, for example 25', will improve the visual uniformity of the National Mall landscape, and will also help inform the selection of young trees for replacement plantings. All trees selected for planting should follow the latest version of ANSI Z60.1 (American Standard for Nursery Stock), and the following list provides additional guidelines:

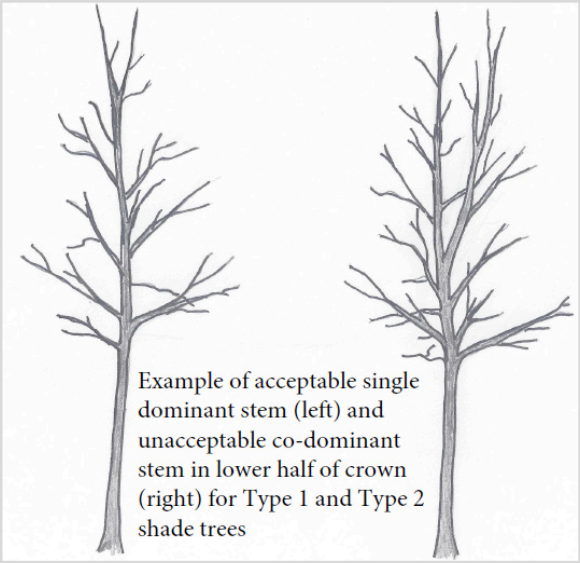
NURSERY STOCK QUALITY GUIDELINES AND SPECIFICATION

- Trees should be freshly dug during the season of planting: March 1st-May 1st for spring planting and October 15th-December 15th for fall planting. No heeled in or cold storage trees will be accepted. Trees should not have growing buds at time of planting in the spring and will have dormant buds in the fall.
- All trees should be grown in USDA hardiness zones 7A or colder to insure appropriate dormancy in the fall and bud break in the spring. Trees should have been grown in the nursery that they are being harvested from for at least 3 years.
- The genus, species and cultivar and/or trademark name of all trees should be clearly and legibly labeled in weather-resistant ink or embossed tag on each plant, as well as on the plant list.

- Tree and root ball size should conform to the latest version of ANSI Z60.1 (American Standard for Nursery Stock).
- Tree caliper should be 3.0-3.5 inches measured on the trunk 6 inches up from the root flare. Tree sizes between 2.0 inches up to 4.0 inches may be acceptable at the discretion of the National Park Service's staff or consulting arborist.
- All trees should be free of insects and diseases. New shoot growth should be greater than 12 inches, as determined by measuring shoot length from the terminal bud scar. The size, color and appearance of leaves should be typical of the time of year. Leaves should not be tattered, misshapen, stunted or off-color.
- All trees should be Balled and Burlapped (B&B) wrapped in natural burlap only and jute twine. Wire baskets are acceptable. Broken, soft or re-balled root balls will be rejected. Root balls should not be allowed to dry out after digging.
- For a 3.0 inch caliper tree, the root ball should have a minimum diameter of 32 inches and minimum depth of 19 inches. A 3.5 inch caliper tree should have a root ball diameter no less than 38 inches and a minimum depth of 23 inches.
- There should be no roots greater than one-tenth the diameter of the trunk circling more than one-third the way around in the top of the root ball. Roots larger than this may be cut provided they are smaller than one-third the trunk diameter. There should be no kinked roots greater than one-fifth the trunk diameter. Roots larger than this can be cut provided they are less than one-third the trunk diameter. The tops of several tree balls may be randomly inspected to ensure that root systems meet the specification.
- Trees should be rooted into the root ball so that soil remains intact and trunk and root ball move as one when lifted. The trunk should bend when gently pushed, not pivot at or below the soil line.
- The point where the top-most root in the root ball emerges from the trunk should be visible at the soil surface. No excess soil will be piled on top of the root flare during the digging process.

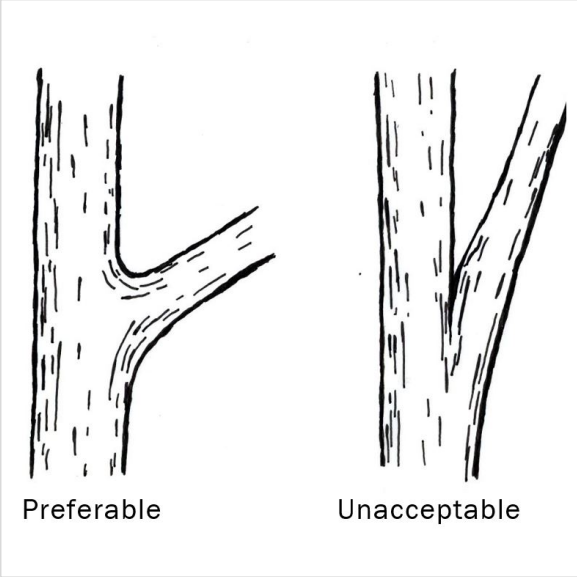


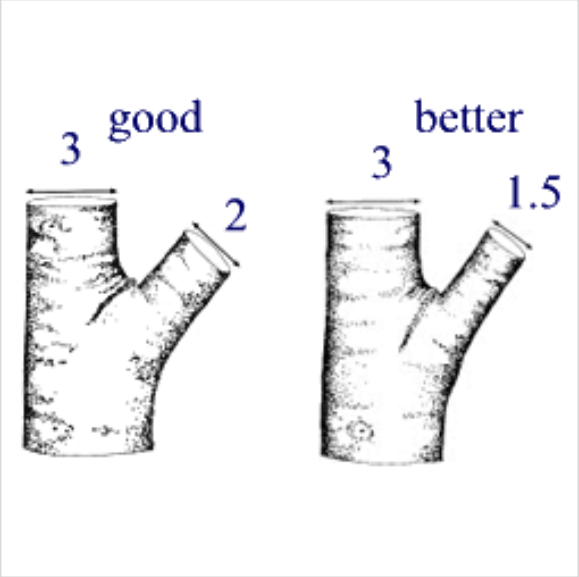
- There should be one dominant leader more-or-less straight to the top of the tree with the largest branches spaced at least 6 inches apart. There can be a double leader only in the top 10% of the tree.



Example of acceptable single dominant stem (left) and unacceptable co-dominant stem in lower half of crown (right) for Type 1 and Type 2 shade trees

- The tree canopy should be symmetrical, free of large voids, and typical of the species or cultivar. Live crown ratio (distance from bottom of canopy to tree top/tree height) should be at least 50%.
- All branches shall be less than two-thirds the trunk diameter, free of bark inclusions, and more-or-less radially distributed around the trunk.





- The trunk and main branches shall be free of wounds (except for properly-made pruning wounds), damaged areas, scrapes, knots, bleeding, and signs of insects or disease. Trees shall not be pruned immediately prior to delivery.
- The NPS has the right to select and tag trees at the nursery. All trees must be approved by the staff or consulting arborist prior to digging and planting.
- If any of the above conditions are not met, trees may be rejected.

PREPARING THE SITE

During the investigation of the soil conditions present on the National Mall, the Cornell team found that the soil around the trees was very compacted and potentially restrictive of new root growth. In order to remedy this undesirable soil compaction, significant site preparation needs to occur prior to planting. We recommend using the "Scoop and Dump" technique, a method which has been validated over a twelve-year study at Cornell University. The following is a description of the process that should occur whenever new trees are being planted on the Mall.

A marker or stake should be temporarily placed where the new tree is to be planted, taking care to make sure it aligns with the established grid layout of the existing trees. Using the stake or marker as a center point, a 15' x 15' square should be marked out on the ground. This is the area of soil to be remediated.

Next, a 6" layer of suitable mature compost (see specification) should be placed on top of the entire 15' x 15' area. A backhoe is then used to incorporate the compost amendment. Working from one side to the other, so as not to run over previously dug areas, the compost and soils should be dug down to a depth of 18" to 20" with the bucket of a backhoe. The bucket scoops up the mixture, lifts it approximately 3' into the air, and then dumps it back to the ground in the same location. The backhoe then moves to the adjacent compost and soil and repeats the process, so that the entire 15' x 15' area is "scooped and dumped." A video showing the process is available at: https://youtu.be/iDEPH7uBxlA.

SPECIFICATION FOR SUITABLE COMPOST

A. Compost for amending the planting site shall be a stable, humus-like material produced from the aerobic decomposition and curing of green waste or food waste or manure feedstocks or those in combination. No municipal sewage sludge should be used as a feed stock. The compost shall be a dark brown to black color and be capable of supporting plant growth with appropriate management when mixed with existing soil. It should be free of free water or dust, with no unpleasant odor, and meeting the following criteria as reported by laboratory tests.

    1. The ratio of carbon to nitrogen shall be in the range of 10:1 to 20:1.

    2. Stability shall be assessed by either a CO2 evolution test, such as the Solvita procedure (Solvita manual, version 3.5). For the Solvita test, the compost must achieve a maturity index of 6 or more. Woods End Research Laboratory, Mt. Vernon, Maine, or approved equal shall conduct stability tests.

    3. Organic Content shall be >20 percent (dry weight). No more than seventy-five percent of the material shall pass a 1.0-inch screen. and no more than 10% of the material shall pass No. 170 sieve (0.088mm). Debris such as metal, glass, plastic, wood (other than residual chips), asphalt or masonry shall not be visible and shall not exceed one percent dry weight. Organic content shall be determined by weight loss on ignition.

    4. pH: The pH shall be between 5.5 to 7.6 as determined from a 1:1 soil-distilled water suspension using a glass electrode pH meter (American Society of Agronomy Methods of Soil Analysis, Part 2, 1986)

    5. Salinity: Electrical conductivity of a one to two soil to water ratio extract shall not exceed 2.0 mmhos/cm (dS/m) for use in blending.

    6. Nutrient content shall be determined by the Cornell University Soil Testing Laboratory or equivalent laboratory and utilized to evaluate soil required amendments for the mixed soils. Chemical analysis shall be undertaken for, Phosphorus, Potassium, Calcium, Aluminum, Magnesium, Iron, Manganese, Lead, Soluble Salts, Cation Exchange Capacity, soil reaction (pH), and buffer pH.

PLANTING THE TREE

The balled and burlapped, 3.0-3.5 inch caliper tree should be planted in the center of the remediated soil, taking care to make sure it aligns with the established grid of existing trees. The planting hole should be dug approximately 20” deep to accommodate the tree’s root ball. Care should be taken to not loosen the soil under the ball. The root ball should be placed on a firm bed of soil at the 20” depth.

The remediated soil should be backfilled around the tree insuring that the tree is upright. The tree should be checked for straightness from two locations that are 90 degrees apart from each other. Once the tree is stabilized, the top third of the wire basket should be taken off and all twine removed. Excess burlap should be removed, and any remaining burlap folded back so that at least the top third of the root ball is exposed.

The remainder of the backfill should be added, taking care to keep the trunk flare exposed at the soil surface. The tree should be watered thoroughly with 20 gallons of water. A 2-3 inch depth of double ground shredded bark should be added in a radius of 6' around the tree and should not touch the trunk. Any portions of the amended area left unmulched will need turf reestablishment. Support systems for the newly planted tree (such as stakes or guy wires) are not recommended unless deemed necessary by the staff or consulting arborist. Care must be taken not to leave these on for longer than necessary, as they can result in damage to the young tree if left on for too long.

POST-PLANTING MAINTENANCE

For the growing season following planting, young trees should be monitored for drought stress and watered using water bags. Bags should be filled at least once per week if there is not a significant rainfall event (more than ¼") the week prior. Any support systems such as stakes and guy wires should be removed once the trees no longer require them.

The Cornell report from 2018 found that the Mall soil had adequate nutrients to support tree growth. No additional fertilization will be needed post-planting unless a soil test report recommended it.

Structural pruning of the new trees should start one year after planting and continue up to five years after planting. Each new tree is to be pruned at least every other year for three pruning cycles. Pruning should adhere to the most recent version of the *ANSI A300 (Part 1) American National Standard for Tree Care Operations - Tree, Shrub, and Other Woody Plant Management - Standard Practices (Pruning) 2017,* as well as the best management practices as outlined in the International Society of Arboriculture's *Best Management Practices: Tree Pruning.*

Besides the published industry standards and best management practices for tree pruning, a few other resources may prove useful for guiding structural pruning activities:

- *An Illustrated Guide to Pruning, 3rd ed. (2012)* by Edward F, Gilman devotes a chapter to structural pruning.
- *Pruning Young Elms: Guiding American, Asian, and Hybrid Elms to Stately Maturity (2010)* by Chad P. Giblin specifically deals with structural pruning of young elms.

Recommendation #9—Soil compaction mitigation and mulching should be a regular part of tree maintenance at the National Mall

One major challenge faced by trees on the National Mall are the highly compacted soils. Protecting soils from further compaction due to heavy machinery or foot traffic is one aspect of controlling this issue. Another aspect involves remediating the compacted soils to improve their ability to support healthy tree growth.

Soil compaction in the root zones of existing trees is sometimes addressed with arboricultural practices such as radial trenching or vertical mulching. By nature, these practices are very disruptive to the soil within the treated tree's root zone. If done properly, utilizing pneumatic (air) excavation methods for these practices to treat soil compaction can reduce the amount of root damage the tree sustains during the treatment. Unfortunately, if these treatments are done improperly, there is a risk of major damage to the root systems of existing trees.

Because of the inherent risks involved with treating soil compaction around existing trees, we are only recommending soil decompaction treatments for new tree plantings on the Mall, using the "Scoop and Dump" method, as described in the prior section.

Providing a mulch ring around all the trees on the Mall is also recommended. The mulch application should be maintained at 2-3" depth and replenished as needed. It should extend 5-6' from the base of the tree, but it should not be in contact with the tree trunk; a 6" space between trunk and mulch should always be maintained. Mulch should be double-hammer milled hardwood bark, and it should be free of deleterious materials.

Recommendation # 10—Consider prophylactic treatment of the "signature" elms with a fungicide for Dutch elm disease

There are a number of large, beautiful American elms on the National Mall, and the Cornell team feels that they should be treated prophylactically with a fungicide registered for use as a Dutch elm disease preventative. Treatment typically is effective for three years.

The inventory identified 15 trees as in excellent condition—of which 8 of those were large, mature specimens. The Cornell team recommends the treatment of these large, "signature" elms with a protectant fungicide. There are two reasons for this—first, that large trees are much costlier to prune and to remove; and two, large trees play an outsized role in creating beautiful spaces and in improving our ecosystem and are thus worthy of efforts to sustain them.

There are two main fungicides that are typically used in the preventive treatment for Dutch elm disease: propiconazole and thiabendazole. Both are injected into the root flares of the elms, and both provide three years of protection against the disease. There are two main injection methods, macro infusion, which uses a larger amount of water to dilute the pesticide, and micro infusion, which uses a smaller amount but is injected under pressure into the tree. Both methods require a trained applicator to use the product, and a significant amount of time to expose roots, drill holes and set up the injection, and time for the tree to take up the dilution completely. All require the applicator to create drill sites around the root flare of the tree, which will take some time for the tree to compartmentalize the wound. One method, the Arborjet Arborplug method, leaves small microport plugs in the tree and the tree grows woundwood over the plastic plugs.

Both chemicals have a lower prophylactic dose level that provides one year of protection and a higher dose level that provides three years of protection. The Cornell team recommends doing the higher dose level every three years to avoid unnecessary wounding of the trees' root flare.

Elm researcher Professor Emeritus R. Jay Stipes, from Virginia Tech wrote of his research into comparing the two fungicides:

> *"Fungicide infusion/injection is a most effective tool in preventing disease, and we might term it as a type of "immunization." Many compounds in past times have been tested in vitro and in vivo, and a few of them employed, but currently, Alamo® (propiconazole; Syngenta AG, Basel, Switzerland) and Arbotect® (thiabendazole hypophosphite; Syngenta AG, Basel Switzerland) are now commonly marketed and used to preclude initial infection, and to treat established disease. Propiconazole is more "tree friendly" (that is, less toxic) than thiabendazole, but propiconazole does not move from treated xylem (wood) to newly synthesized wood following injection as thiabendazole does. Further, infusion of larger volumes of propiconazole has been found to provide better (more uniform) translocation than concentrated concentrations applied via micro-injectors, when both are used at the recommended dosage rate based on diameter at breast height (d.b.h.). Even though propiconazole residues cannot be detected more than a year or so after infusion, protection from disease continues to occur. The late Mark Stennes and I theorize that a phytoalexin-like response is induced by the fungicide, thus lending disease resistance years following fungicide application".*

--Dutch Elm Disease: An Overview of the Biology and Management Regimens, R. Jay Stipes, *Proceedings of the American elm restoration workshop 2016-- Elm Pathogens,* 2016

Recommendation

We recommend that "signature" trees be treated every three years with a prophylactic Dutch elm disease fungicide treatment, either propiconazole or thiabendazole. The following trees are considered worthy of treatment: 50-11, 16-16, 4-18, 50-9, 43-4, 43-1, 41-6, 13-21. The treatments should be done by a tree care company that is licensed to apply pesticides and has experience in the macro or micro infusion methods these fungicides require.

The following information, taken from the manufacturers' labels, is for the three main products used for Dutch elm disease management.

Arbotect 20 – S Fungicide (Thiabendazole) macro infusion

Elm Trees – 3-Year Growing Season Treatment – For Preventive Treatment of Dutch Elm Disease

Inject 12 fl. oz. of Arbotect 20-S for each 5 inches of trunk diameter. Dilute each 2.0 fl. oz. of Arbotect 20-S with 1 gal. of water. Inject into any exposed root flares, below ground, once every three years. Place injection sites into root flares at 3-10 inch intervals around the tree with a maximum hole diameter of 1/4 inch. Where needed, the root flares will need to be exposed through soil excavation. Trees treated into trunk wood will not be as effectively protected.

A typical tree will require 1.3 injection sites per diameter inch. For best results, injections should be made after the tree is fully leafed and the seeds have dropped, through late summer or early fall. Do not use this treatment if trees are less than 10 inches in diameter.

Retreatment Arbotect 20-S will provide three growing seasons of protection in most situations. However, protection in the third year after treatment will be slightly less than the first two years. In high disease pressure situations and for trees over 30 inches in diameter, retreatment may need to be considered during the third growing season after the tree was initially treated.

Alamo Fungicide (propiconazole) macro infusion

DUTCH ELM DISEASE IN ELMS Preventive and Therapeutic Treatment

Use 6-10 ml of Alamo in up to 1 liter of water per inch DBH. For very high disease pressure, 20 ml of Alamo per inch DBH may be used.

(1) Accurate diagnosis of Dutch elm disease is important since Alamo only provides control of Dutch elm disease in elms.

(2) Alamo will be most effective when used in conjunction with other cultural practices recommended for management of Dutch elm disease (removal of dead elm trees, pruning of diseased tree limbs and branches, control of bark beetles, etc.).

(3) Preventive applications can be made at 6-10 ml/inch DBH. The 6 ml rate should provide 24 months control and the 10 ml rate should provide 36 months control.

(4) Therapeutic treatment in trees showing disease symptoms should be made at 10-20 ml/inch DBH. Retreatment may be needed every 12-36 months. Trees in advanced stages of disease development may not respond to treatment. For further information on the proper diagnosis and control of Dutch elm disease, consult your local extension agent. See the Product Information section for details on retreatment.

Propizol (propiconazole) micro infusion

Trunk Injection into Trees: Inject at the base of the tree. Apply the entire mixed dose in the trunk flare root or within the first 3 feet of trunk height favoring a height lowest to the ground. Trunk flares are best; avoid flat spots and damaged wood areas.

Always inject into healthy portions of the trunk or trunk flare. Inject the tree by placing an Arborplug® or STINGER tip hole every 3-6 inches around the tree using one of the tools below.

Do not place injection sites closer than 2" apart. If using an alternate trunk injection tool follow the instruction that best fits your delivery tool.

Using the STINGER Tip Use a sharp, clean 7/32" diameter high speed drill bit. Drill holes into the sapwood a minimum of 3/8" (and typically 5/8") deep. Push STINGER needle into hole and twist right for a snug fit; start application, and remove the STINGER needles upon completion. The STINGER Method requires no Arborplugs. Clean and disinfect needles between trees.

Using Arborplugs® Use a 9/32" diameter high speed drill bit for the #3 Arborplug (or 3/8" diameter high speed drill bit for the #4 Arborplug). Drill bits should be clean and sharp. Drill holes into the sapwood a minimum of 5/8" deep. Insert the Arborplug, countersink to the thickness of the bark using the set tool and hammer. Inject by inserting the VIPER needle, start application, and remove the VIPER needle upon completion. The Arborplug will remain in the tree. Clean and disinfect needles between trees.

Retreatment: At the initial injection of this product, take notes on the level of disease in each tree. Reevaluate disease level in trees at 12-month intervals after treatment for the potential need for retreatment with this product. Preventive applications should be considered 12-36 months after the initial injection. Trees in high disease risk areas or high value trees should be evaluated for possible retreatment 12 months after each treatment.

Future injections in the same tree are applied into new holes placed intermediate to the old injection sites. Drill new sites either above or below (by 2" vertically) to the old sites and 2 to 3" horizontally from them. Applied correctly, this will form a triangular pattern with the old sites. Follow application procedures described above for repeat injections.

Recommendation # 11—National Park Service tree care personnel should participate in ongoing technical tree care training

The tree care industry's standards are constantly evolving—so much so that the standards (ANSI A300 and ANSI Z133) that tree care companies are expected to adhere to are updated every five years. The Cornell team recommends that all NPS staff that work on the trees or plant replacement trees be trained in the latest industry standards. In addition, turf management crew leaders should likewise be trained in how to avoid or minimize tree damage during their routine maintenance. The staff arborist or consulting arborist would be tasked with providing face-to-face and hand-on training for NPS tree care staff.

The ANSI A300 standards are developed by a group of industry leaders in a process that allows for a great amount of practitioner input. The most current ANSI A300 standards are:

Part 1: Pruning, 2017

Part 2: Soil Management-Fertilization, 2018

Part 3: Supplemental Support Systems (e.g. Cabling/bracing), 2013

Part 4: Lightning Protection Systems, 2014

Part 5: Site Planning and Development, 2012

Part 6: Planting and Transplanting, 2018

Part 7: Integrated Vegetation Management, 2012

Part 8: Root Management, 2013

Part 9: Tree Risk Assessment, 2017

Part 10: Integrated Pest Management, 2016

The most current safety standard is the ANSI Z133 Arboricultural Safety Standards, 2017.

The standards are available for purchase from the International Society of Arboriculture (http://www.isa-arbor.com/), or from the Tree Care Industry Association (https://tcia.org/) . In addition to these standards, the International Society of Arboriculture has published companion pieces to each standard called Best Management Practices (BMPs). The BMPs are written in easier to understand language and cover the basics of industry standard care. Many of the BMPs are available in Spanish and the NPS should have these Spanish-language BMPs if they would be of use to members of the NPS crew.

The NPS crews who work on the trees should be familiar with the BMPs of pruning as well as planting and transplanting and fully familiar with the ANSI Z133 Arboricultural Safety Standards.

Any contracted crew that the NPS employs to work on the trees should likewise adhere to all A300 standards as well as the Z133 safety standards, and this should be explicitly outlined in the contract for work.

Recommendations

- *The NPS tree care crew should have access to the latest versions of the ANSI A300 standards and the BMPs for each standard, with Spanish language BMPs available if it will be helpful to crew members.*
- *The NPS tree care crew should participate in ongoing training in arboriculture and the ANSI Z133 safety training. Training could include tailgate trainings, mentoring by the staff or consulting arborist, or attendance at regional tree care conferences such as the Tree Care Industry Association or the Mid-Atlantic Region of the International Society of Arboriculture conference.*
- *NPS management should foster an environment for the safe practice of arboriculture and encourage crew members to advance their technical knowledge. The management should also seek on-the-ground feedback about trees of concern so that any tree issues can be dealt with on a timely basis.*

Recommendation #12—The National Park Service and its subcontractors should follow industry best practices in all aspects of tree care

This Operations and Maintenance Guide has covered many aspects of tree care and maintenance. Planting, pruning, tree protection, and pest management are the most important tree care areas, and all work done should be in accordance with the respective ANSI A300 standards and Best Management Practices. There are a few other tree care and maintenance areas this Operations and Maintenance Guide has yet to cover. In our tree inventory and visual tree risk assessment, the Cornell team noted when we saw trees that had been cabled, as well as when there were cables that had failed. In many cases, the cables were installed just a few feet above a fork, which is not in accordance with current cabling practices and the ANSI A300 Part 3 standard. Cables should be installed well up in the canopy of the tree– the standard says the cables should be located two-thirds the distance from the fork to the edge of the canopy. Since installing cables is not likely to be done by the NPS crew, but rather subcontracted out to a tree care firm, the Cornell team recommends that the contract state that all work shall be done in accordance with the ANSI A300 Part 3 standard, and the work will be inspected by the staff or consulting arborist prior to payment.

Working on the National Mall presents its own set of challenges. While the NPS crew is well aware of the dangers of working in a highly public, pedestrian-oriented space, outside contractors may not be so attuned. Prior to signing a contract with a subcontractor, the NPS staff should require the subcontracting company to outline the steps their crew will take to keep the area safe for both their workers and the public. The work area should be roped or taped off with high visibility material and signage. There should be at least one ground worker whose sole task is to monitor the roped-off area to keep pedestrians out of the work area. Failure to secure an area during work should be grounds for an immediate stop work order.

Recommendations

- *Should the NPS need to subcontract out tree care work, the contract should be developed to outline adherence to all relevant ANSI A300 and ANSI Z133 standards*
- *The contractor shall secure the work area and dedicate one ground worker to keep pedestrians out of the work area*
- *All subcontracted work should be inspected by the staff or consulting arborist prior to payment*