Japanese Garden Inventory and Management Plan for Maymont Park – Richmond, VA

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(ABSTRACT)

A woody plant inventory was conducted at Maymont Park in Richmond, VA to assess species composition and plant condition of its Japanese garden. This garden has changed significantly over the years, thus requiring a plant inventory. A global positioning system (GPS) unit and data logger were used to locate plants and document their characteristics. Management needs, plant condition, geographic coordinates, accession dates, and trunk diameter were recorded for each of the 333 specimens inventoried in the garden. The project's overall goal was to provide recommendations to help Maymont staff make sound arboricultural decisions. The project was also a pilot to develop a plant inventory protocol for the other 106 acres of the Park. The majority of inventoried trees had 0.5–10 inch trunk diameter at breast height with a few trees measuring over 40 inches. These data revealed that the plant collection consists of mostly smaller, immature trees and that most will need a high level of care to maintain the garden's longevity. The five most abundant species were bald cypress (*Taxodium distichum* (L.) Rich.; 18.6%); 'Yoshino' Japanese cedar (*Cryptomeria japonica* (L.f.) D. Don; 10.8%); Japanese maple (*Acer palmatum* Thunb.; 9.9%); loblolly pine (*Pinus taeda* L.; 8.1%); and sweetgum (*Liquidambar styraciflua* L.; 4.5%). The inventory revealed that mulching, pruning, and tree removal were the most common management needs. Although the garden needs attention in some areas, it is in good condition overall.

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CHAPTER 1 – INTRODUCTION

Project Overview

The purpose of this project was to inventory woody plants in Maymont's four-acre Japanese garden in order to enhance management. Woody plants in the garden were inventoried to improve management. This inventory was also a pilot project to inform how the other 106 acres of woody plants at Maymont should be inventoried. Managing this urban forest will be easier once the plants are located, inventoried, and assessed. Better management will lead to better overall health, safety, and appearance of trees on the estate.

Methodology of data collection and storage was a primary focus of this project as Maymont does not currently have a protocol for mapping its urban forest and will need a standard of collection for the entire 110 acres. With an inventory protocol in place, managers of the estate will save time and money by assessing the big picture first and then focusing on plants as individuals. Garden inventories like this allow managers to look at the entire makeup of a garden in way that was not possible prior to geographic information system (GIS) technology. If large groups of plants within the same genus can be managed together, then managers can prescribe best management practices in accordance with the particular demands of species located within the garden.

The Japanese garden was the scope of this project. Maymont's entire 110-acre estate will be mapped by spring 2009 to increase management efficiency. This project serves as a model for how other sections of the estate will be treated in regards to

inventorying woody plants. Maymont's geography is currently broken into fourteen rough-sketch maps, three of which depict the Japanese garden.

Outcomes of this project include enabling urban forest managers to assess trees easily, manage tree care problems, and provide proper care throughout the years to come. In the future, geographic coordinates of trees can be given to the City of Richmond and commercial tree care firms to assist in locating trees when their services are required. The inventory will also allow arborists to manage trees according to taxon, as similar species usually require similar management. An example of this technique would be using the database to locate all Japanese maples so that they can be pruned before spring to minimize sap bleeding from pruning wounds. The database will also allow managers to track diseases on specimens throughout the park. Pruning, mulching, and fertilizing will also be easier if one knows exactly where trees are and what they need.

Previous data were recorded on the trees and the last time the database was updated was 1995. This project was designed to modernize the inventory from the primitive hand-drawn maps that previously existed to a GIS using global positioning system (GPS) coordinates for each plant. Additionally, plant attributes were also recorded to provide management suggestions. Hopefully, the project will allow managers at Maymont to better manage their urban forest and extend the life of the plants found there.

The inventory gives Maymont an idea of where it has been and where it is going in terms of woody plant care. As time progresses, there should be a smoother transition between managers of the park. The secrets of the landscape will be passed down from generation to generation using this technology, and vital plant statistics will not need to be re-documented every time a new manager comes to the estate.

This project benefits the Japanese garden by allowing managers to examine its woody plants closely and remove or add specimens to meet objectives. Managing the garden effectively will lead to an overall better appearance and a more pleasant experience for visitors. Visitors will also benefit from a safer forest with fewer hazards as such plants will be removed based on the inventory. Fewer hazards means that litigation risks should decrease – lawsuits are a public park manager's worst nightmare.

In this paper, the reader will find the results of the woody plant inventory in the Japanese garden, including species composition, condition assessment, management needs, and size distribution. Also included are maps, a tabular database, and a GIS that integrates tabular data and geospatial data. Finally, recommendations are provided for improving overall garden management as well as management of notable plantings within the garden.

A Brief History of Maymont Park

Maymont Park is a public estate that was bequeathed to the City of Richmond by James and Sallie May Dooley following Sallie's death in 1925. Maymont, an elaborate

Gilded Age estate, was named to honor the family of Sallie May. Prior to the Dooley's purchase, the 100-acre estate was a rolling tract of farmland located next to the James River. The property design was completed and installed in 1893 (Garrett-Cox, Maymont Manager of Historical Collections, personal communication). For its time, Maymont was a prestigious estate and still attracts visitors due to its timeless beauty.

Cattle were raised on the land, and the rich soil that developed there allowed Mrs. Dooley to practice her love for horticulture. The Dooleys grew a wide variety of plants, and Sallie May had extensive gardens with exotic plantings. Traveling was a passion of the Dooleys, and their gardens reflected styles from all over the world. Italian-style, as well as Japanese-style gardens were created and were considered on the cutting edge for their time (Garrett-Cox, Maymont Manager of Historical Collections, personal communication).

The park opened to the public in 1925. When the City of Richmond could no longer bear the burden of management, the city bequeathed the park to the Maymont Foundation to oversee its operation and upkeep. Since 1975, the private, nonprofit Maymont Foundation has operated the park and has relied primarily on donations for its operation. Today, Ikebana of Richmond Inc. and federal grants are the major funds supporting the Japanese garden. The park's urban forest is extensive and includes roughly 3,500 woody plants. There are roughly 138 different genera and 280 different species of woody plants in the park (Singlemann, Director of Horticulture, personal communication). Currently, the park is 110 acres (Figure 1.1) and managed by four

horticulturalists whom, along with an extensive volunteer group, oversee the care of the plants.

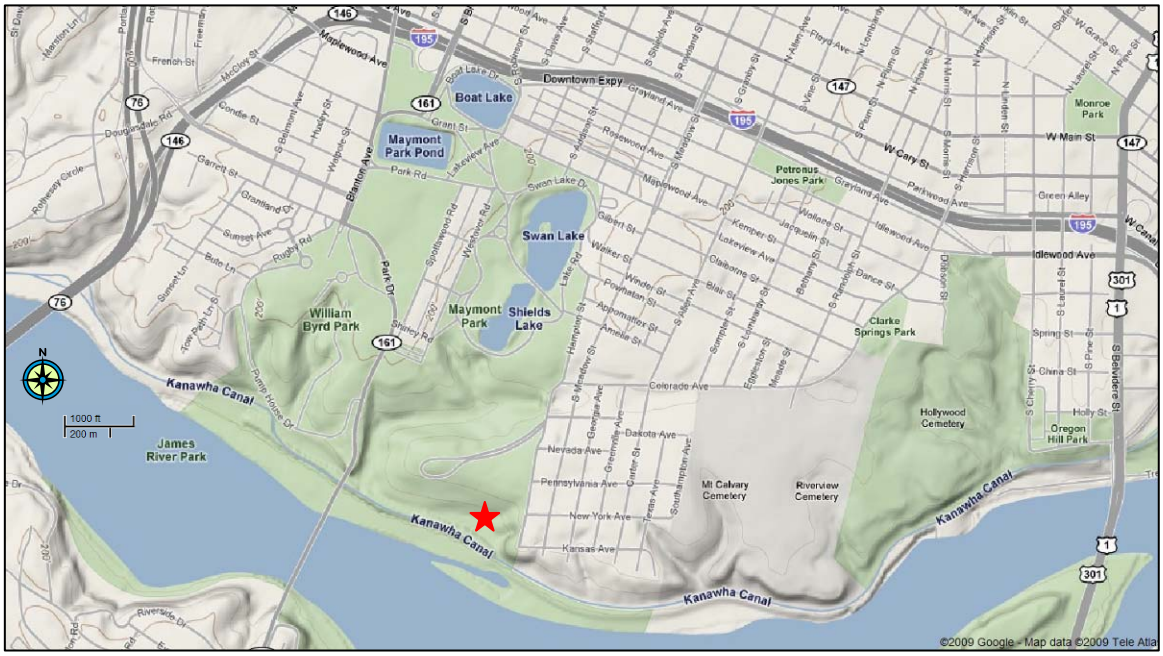

Figure 1.1 – Map of Maymont Park, located on the James River about 2.25 miles west of Richmond, VA. Red star shows the approximate location of the Japanese garden within the park.

The Japanese Garden

Muto, a master Japanese gardener, is believed to have created the garden in 1911. Originally, the garden was considerably smaller, containing the winding watercourse, stone lanterns, and some native Japanese plants. A grotto made from excavated cave material was incorporated into the early design and is still fed by a natural spring. A forty-five foot waterfall, supplied by the Kanawha Canal, is operational from spring until fall. The garden is a hill-and-pond style garden like those created for the rich nobles in China around 200 B.C. The garden also lends itself to the stroll-style garden, which allows visitors to view plantings from several angles (Horton and Crocker 1989).

The Japanese Garden was expanded in 1978 by Barry Starke of Earth Design Associates, and many changes were made from Muto's original design. Stepping stones, a moon bridge, carefully pruned trees, raked sand pools, and a plank bridge were added to slow down the stroll through the garden so that its features could be better appreciated (Garrett-Cox, Maymont Manager of Historical Collections, personal communication).

In October 2008, the garden was renovated through a memorial grant and this allowed for a closer look at what species it contained. Ikebana Corporation of Richmond, a large donor to the garden, contributed the funds on behalf of a deceased member. This renovation cleaned up the island, provided several new plantings, and installed two rock benches. Weeping cherries (*Prunus* spp.), Chinese hollies (*Ilex cornuta* Lindl. & Paxton), and Japanese maples (*Acer palmatum* Thunb.) were among the species added. Today, the garden is four acres and has several prominent features including Koi fishponds, a waterfall, and over 300 woody plant specimens. The trees are the most prominent vegetation in the garden, and inventorying them is of utmost importance for management applications.

The Japanese garden is an important historic site for Richmond as it is one of the premier Japanese gardens of the early 20th century. Its historical significance and service to the public make this park extremely important. Public parks like Maymont often are the largest collections of trees within urban environments. Sporadic tree plantings throughout city blocks are normal in Richmond, and the concentration of trees at Maymont is a treat for visitors. Plant name plaques and group plantings can be useful

teaching tools and the public can take advantage of this garden 365 days a year. When people see parks like Maymont, they often first notice the large, old trees. These trees are living proof that trees outlive many of the visitors here and this contributes to the public's overall appreciation of trees. Community involvement in tree plantings at Maymont helps volunteers socialize and improve the community they live in. This urban forest not only improves the local ecosystem, but also provides opportunities for a better community.

Although the Japanese garden is historic, it is not subject to the same regulations as the other parts of the park. Other gardens in the park must have new plantings approved by the historical society, but the Japanese garden is not subject to such regulations, which can cause rapid changes in planting. Horticulture here is a priority for managers of the estate, and the Japanese garden is a premier site for exemplary horticulture.

Tree Inventories

Tree inventories are performed to inform managers about the types of trees they manage and the needs of particular specimens within their forests or arboretums. These surveys allow managers to track the health and diversity of urban forests throughout time, as populations of trees are always subject to change (Ricard 2008). Inventories are used in the business world to give managers an idea of what they are working with and how to manage what they have. A tree inventory is no different.

The most important application of a public park inventory is to prioritize the maintenance of hazardous tree conditions, like decaying limbs, in order to reduce the potential liability with the public. In addition to hazards, most managers like to track the progress of their plantings through time. Tracking trees through their lifespan allows managers to fertilize, mulch, prune, and perform any other needed cultural practice more efficiently. Inventories are valuable for tracking pest problems, pesticide usage, and solving pathology problems that can often baffle managers. Trees are organisms that can easily outlive those that care for them. Keeping track of what they are and how they were grown requires several generations of record keeping. Tree inventories can bridge the gaps between managers and facilitate garden planning, which is essential to the urban forest's sustainability.

Selecting appropriate tree attributes to measure during an inventory is very important. Ricard (2008) states, "Only data that will be put to use should be collected, bear in mind that information translates into expense: the more data gathered on each tree, the greater the cost of the inventory." A high-quality inventory includes land coordinates taken with a global positioning system (GPS), species names, management needs, and condition status. Damage to trees may also be vital information if the trees are being assessed for hazards. Site notations can be used to identify soil types, anaerobic conditions, and root zone constrictions. Historic trees, which occur at Maymont, can also be noted in a tree inventory and can help justify management based on their value. Databases are created to keep track of the trees and can be referenced easily using

coordinates or plant identification numbers. It is now common to integrate tree inventory databases into a GIS for storage, analysis, and display.

There are several types of tree inventories available for managers to use. The most common types are specific problem, partial, and complete inventories (Ricard 2008). Specific problem inventories assess just that, trees with specific problems. Partial inventories record data on trees of interest, usually of a common genus or a group of historic trees. Complete inventories census an entire area, accounting for every tree. Complete inventories can be expensive, but they provide the most data for managers. A complete tree inventory was conducted for Maymont's Japanese garden.

Urban foresters often choose to conduct inventories in winter (Ricard 2008). Winter is preferred because deciduous trees are defoliated, which allows managers to see and better assess structural defects Also, foliage on trees can block satellite signals, which makes it difficult to acquire accurate GPS coordinates during the growing season. Most horticulture work slows down during winter, so more time is often available for conducting inventories. However, the growing season does allow managers to see pest problems that are dormant during the winter and to better assess tree health.

The Japanese garden inventory served as a pilot study for the entire Maymont estate. GPS technology was new to managers and the garden was suitable size to know if the tool was appropriate for Maymont's management team. In particular, GPS offsetting, plant numbering, and attribute fields needed to be tested. The garden is located in a low

region near the river; this can limit the ability of the GPS to pinpoint locations because landmasses block satellite signals. If the coordinates could be collected here, then this technology could be used anywhere in the park. Due to its difficult nature, inventorying this garden first helped identify issues and solutions in our data gathering system.

CHAPTER 2 – METHODOLOGY

A complete inventory of woody plants in the Japanese garden of Maymont Park was conducted during fall 2008. Data were collected using a high performance, sub-meter GPS receiver combined with a rugged handheld computer (Trimble GeoXT, Trimble Navigation Limited, Sunnyvale, CA USA). The inventory project, from planning to analysis, was conducted in three stages – pre-field work, field work, and post-field work. The following is a description of procedures used during each stage.

Pre-Field Work

Prior to actual data collection, considerable planning went into the inventory project. First, a preliminary overall assessment of the Japanese garden was made. A rough map was obtained from Maymont managers and was used to identify the general location of trees. Fallen trees, new plantings, and removed trees had not been accounted, so these all needed updating. Severe weather such as Hurricane Isabel in 2003 made this map outdated.

The geographical limits of the inventory were designated by pre-existing boundaries in the garden that were drawn according to easily distinguished landmarks. The south boundary was established at the fence that ran along the Kanawha Canal and James River. Fencing along the east side allowed for another easily distinguished boundary. Northern boundaries were drawn from the point where the trails opened up to provide a view of the garden. Roughly 50 yards of trails were included within the northern border. Most noticeable of all the features along the north side is the Grotto,

which is a main attraction. Flowing water from the Cliffside was the northernmost feature and allowed for all plants within the waterfall area to be included in the inventory. Western boundaries were drawn at the entrances, both public and utility.

We chose to inventory all woody perennial plants except azaleas, which will be inventoried and categorized according to bloom color during the growing season in 2009. Plant attributes documented in the inventory included species name (botanical and common), accession date (if known), trunk diameter, condition status, and management needs.

The accession date was the date of planting for individual woody plants or groups of plants. Many plants in the Japanese garden did not have the date of planting or the origin, but those that did were added to the inventory whenever possible. Most current managers keep accession information in their head due to the fast pace nature of public park management. With an inventory, the information will be accurately stored and readily available to facilitate future management.

The tree measurement made most frequently by urban foresters is diameter at breast height (DBH). This measure is defined by stem diameter outside the bark at a point 4.5 ft above the average ground line on the uphill side of the tree. DBH is a reliable predictor of tree age and height. A special tape measure, which converts trunk circumference to diameter, was used to measure DBH. DBH measurements were not made on shrubs due to their multi-branched architecture and small size.

Plant condition was categorized as good, fair, or poor. Good condition designated a plant with good architecture, no pest problems, and high vitality. Fair condition designated a plant with minor architecture problems, minor pest problems, or diminished vitality relative to other specimens planted at the same time. Poor condition designated a plant with major architecture problems, major pest problems, or extremely stunted growth. In most instances, the cause of diminished condition was noted in the comments section so that the problem could be corrected later. An example of a minor architectural problem is a small-diameter, decaying branch that requires pruning. An example of a major architectural problem is large-diameter, cracked trunk that requires tree removal.

Management needs of individual trees were a subjective measure and no standardized values were used. As trees were inventoried, the obvious needs of individual plants could be seen. Comments on management needs were manually entered into the data logger. Pruning, mulching, vine removal, tree removal, epicormic sprout removal, narrow branch crotches, pest problems, fertilizing, and other cultural practices needed to improve plant condition were noted here.

Field Work

Field work was performed during a two week period in December 2008. Inventorying was conducted between 8:30 a.m. and 4:30 p.m. GPS coordinates of the plants were measured using the following coordinate system: NAD 1983 UTM 17N – meters. GPS satellite availability was reviewed each day to identify the best timeframe to collect inventory data under good satellite geometry. Times varied every day and

collectors adjusted their schedules accordingly. The following tools were used during the daily data collection:

- Trimble GeoXT GPS receiver and field computer
- Digital stem caliper and DBH tape
- Hand-drawn map of the Japanese garden
- Existing database (c. 1995) of the Japanese garden
- Handheld compass for offsetting GPS points

Plant mapping techniques were very similar to any point-based data collection system. First, satellite reception was assessed. If the GPS unit functioned directly under a tree, the coordinates were recorded by standing against the trunk and facing due south. This consistent south stance allowed for the best satellite reception and kept data recording consistent.

If no satellites could be picked up directly underneath the tree, then offsetting was needed. Offsetting a tree's position was accomplished by finding a spot where satellites would reach and taking the point there. Then the option menu on the GPS allowed the collector to offset the position using directional bearing and distance measurements. Offsetting was a very useful technique since several trees in the garden were on a hill or were in vegetation too dense (e.g. bamboo) to measure geoposition from their exact location. Fencing, rocks, and other trees also presented problems in collection because they interfered with satellite signals.

As each plant was logged into the GPS, its other attributes were also recorded. The inventory was much more efficient with two people as one person did the measuring while another recorded. As some trees were very large (in excess of 33 inches DBH), two people were often needed to measure DBH. Condition status and management needs of the plants were also assessed while the coordinates were taken. Accession dates for the plants were updated on the unit later from Maymont's files. A request was made of many nurseries throughout the state to provide dates of past plant orders to fill gaps in knowledge of planting dates.

Post-Field Work

After field data were collected, each database file was written as a "shape" file (geospatial vector data format for GIS software) from the GPS unit and stored on a desktop computer. Files were then renamed according to the date so that individual data folders could be separated. Accession dates, if available, were updated in the files for each plant. Additional plant attribute information that could not be collected in the field was also entered and errors and omissions in the database were corrected. Tabular data were exported to a spreadsheet application (Microsoft Excel 2003, Microsoft Inc., Redmond, WA USA) for calculating descriptive statistics and producing charts. Shapefile data were exported to a GIS application (ArcGIS 9.1, ESRI Inc., Redlands, CA USA) for storing geospatial data and producing inventory maps.

CHAPTER 3 – RESULTS

In the Japanese garden, 333 woody plants were inventoried; 286 of these were trees (Figure 3.1). Forty-eight different woody plant species were catalogued. The most

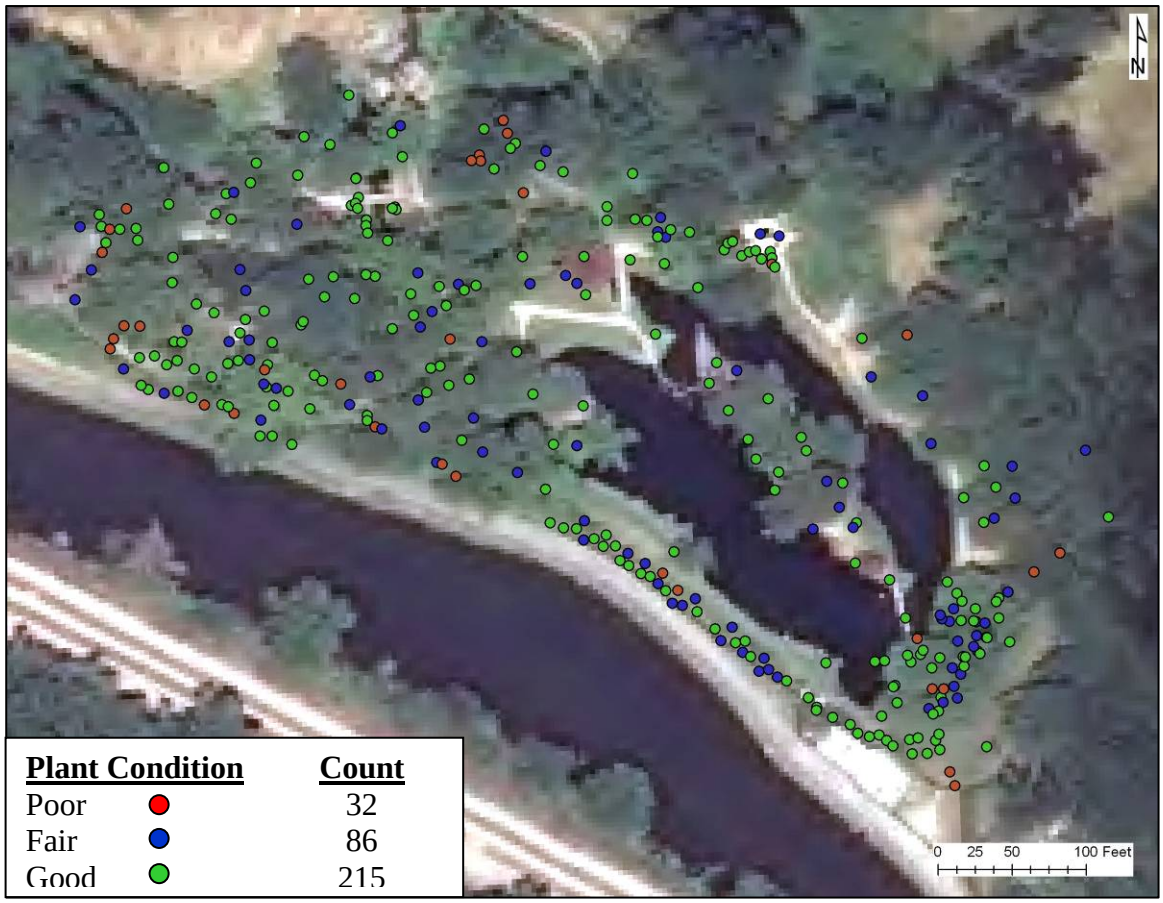

Figure 3.1 – Map of the Japanese garden at Maymont Park showing the location and condition of inventoried woody plants (333 total plants).

abundant species was bald cypress (*Taxodium distichum* (L.) Rich.), which accounted for about 18% of inventoried plants (Figure. 3.2). Other abundant species included 'Yoshino' Japanese cedar (*Cryptomeria japonica* (L.f.) D. Don), Japanese maple (*Acer palmatum* Thunb.), and loblolly pine (*Pinus taeda* L.), each accounting for about 8–10% of inventoried plants (Figure 3.2).

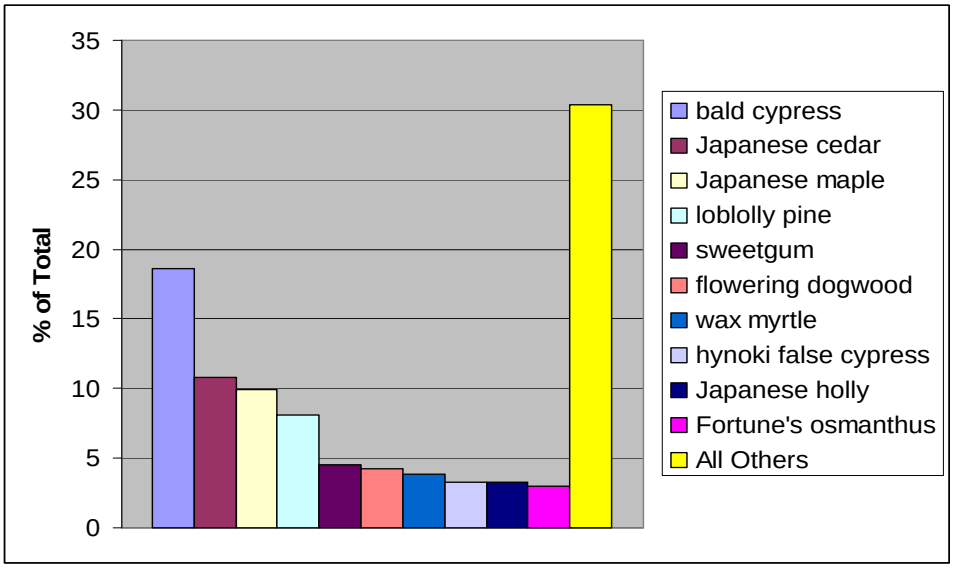

Figure 3.2 – Relative abundance of top ten most abundant species inventoried in the Japanese garden at Maymont Park–Richmond, VA (333 total plants).

The majority of inventoried trees had 0–10 inch trunk diameter with a few trees measuring over 40 inches (Figure 3.3). 'Yoshino' Japanese cedar accounted for the

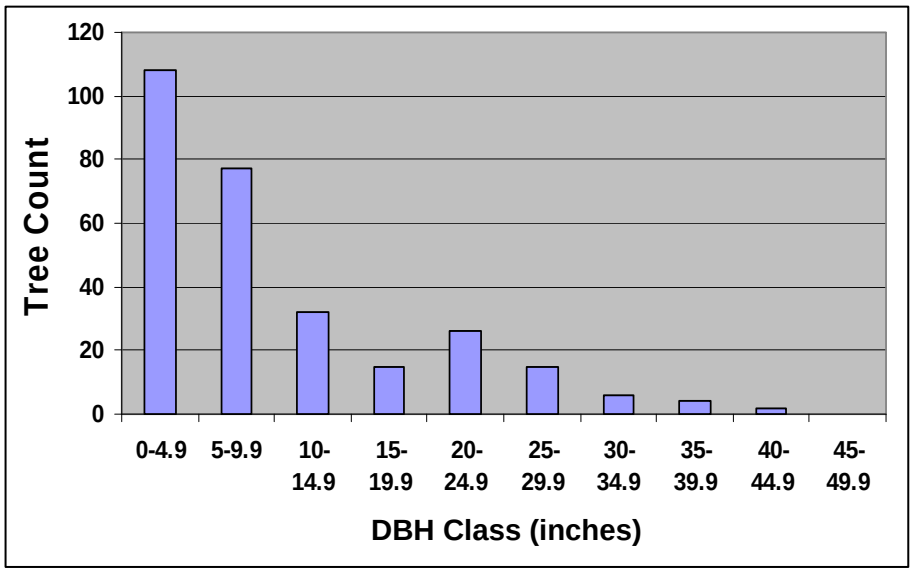

Figure 3.3 – Trunk diameter at breast height (4.5 feet above ground line; DBH) of trees inventoried in the Japanese garden at Maymont Park–Richmond, VA (286 total plants). Shrubs were excluded from the analysis.

majority of small stature trees whereas bald cypress accounted for the majority of large stature trees. The largest specimen inventoried was an American sycamore (*Platanus occidentalis* L.), which measured 43 inches DBH.

The majority of inventoried plants were in good condition (Figures 3.1 and 3.4). Species that were generally in good condition included Japanese maple, Fortune's osmanthus (*Osmanthus* × *fortunei* Carriere), and bald cypress. There were about 30 plants in poor condition. Species most commonly in poor condition were Virginia pine (*Pinus virginiana* Mill.), Korean pine (*Pinus koraiensis* Siebold & Zucc.), and loblolly pine.

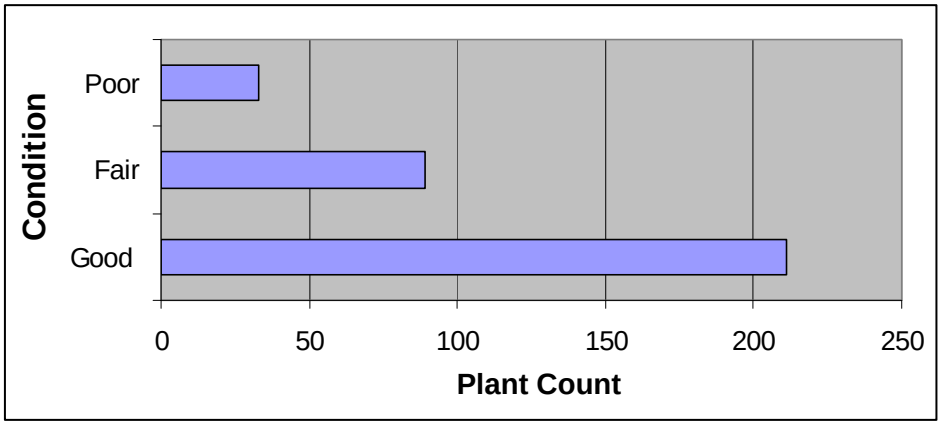

Figure 3.4 – Condition of woody plants inventoried in the Japanese garden at Maymont Park–Richmond, VA (333 total plants).

The inventory revealed that 37 trees needed pruning; evidence of past improper pruning was noted. The inventory also revealed that 113 trees and shrubs needed mulching, 38 needed removal from the garden, 3 needed fertilizing, 4 needed vines removed, and 4 needed pest management.

CHAPTER 4 – DISCUSSION

General Management Recommendations

The Japanese garden inventory should be updated every five to ten years to keep an accurate record of the woody plants. In addition, the property should be assessed on a regular basis (annually and after severe weather events) for hazardous trees as these are the biggest risk for Maymont as a public facility. Pruning and removal needs should be prioritized based on the value of the specimen or the impact of the defective branches on plant health, safety, or appearance. A full-time, professional arborist position needs to be created to ensure the health and longevity of the trees at Maymont.

Mulching was by far the greatest need for the garden. According to Vertrees and Gregory (2001), "Mulching serves several useful purposes – to maintain weed free conditions, to minimize water loss in dry spells, and to provide winter protection for the roots in prolonged freezing conditions" (p. 62). Mulch should be laid down in the fall before the first frost and can be purchased in 100-yard bulk loads to save money. If mulching continues to be neglected, then overall plant health may fade with time.

Plant composition in the garden included a large diversity of species. Removing some tree species and planting new ones would mitigate some current management issues and add to the overall beauty of the garden. The north entrance to the garden needs Sargent juniper (*Juniperus chinensis* L. var. *sargentii* A. Henry), bamboo, and hanging branches removed. The Sargent junipers found along the walkway have been dead for a while and have turned brown, leaving the public a poor view as they approach the garden.

All of the sweetgums (*Liquidambar styraciflua* L.) should be removed due to their poor appearance and need for intensive cleanup. Also, all of the bamboo (*Bambusa* spp.), except for that growing on the north bank, should be removed because of its invasive nature. The north bank of the garden has an extremely steep slope and the bamboo helps minimize soil erosion there.

Adding some additional trees will improve the overall diversity of the garden. Full moon maple (*Acer japonicum* Thurb.) would be the best addition to help moderate the overabundance of Japanese maples. Also, since Japanese maples have long been cultivated by the Japanese, a planting of several rare and beautiful species on the island near the *Azumaya* (traditional Japanese building) may be well suited. Japanese maple is not overly competitive and can coexist with practically all landscape plants (Vertrees and Gregory 2001), so additional planting should not be problematic. Rhododendrons, azaleas, and blooming perennials would make nice complimentary plantings to the Japanese maples. Any maples to be added should be balled and burlapped (B & B) instead of container grown as this species is reported to do best with this nursery stock type (Dirr 1998).

Recommended Japanese maple varieties for fall color display on the island are 'Kinshi', 'Shishigashira', and 'Golden Pond'. These trees yield orange–yellow, golden red, and yellowish orange fall colors, respectively. They would be nice complimentary trees to improve the majestic look of the island. Spring color display can be improved by adding 'Orange Dream', 'Beni Maiko', 'Katsura', and 'Coral Pink'. These trees will

yield an orange, red, orange, and pink spring foliage display, respectively (Vertrees and Gregory 2001).

Acer palmatum 'Dissectum' varieties should be used to accent water pools, waterfalls, and winding paths where appropriate within the garden. The south edge of the pond is a particularly good place for a mass planting of these smaller stature trees. New plantings of any kind would add an easier to manage age structure and any aesthetically pleasing plant should be considered.

Prized ornamental trees on the property should be propagated to serve a fundraising need for the Foundation as these trees, if propagated properly, can yield great profits. Many of the Japanese maple varieties propagate from seed and cuttings so this would provide plant material to sell at Maymont events like Herbs Galore as well as the Maymont Flower and Garden Show.

Plant Pruning

Best management practices should always be used when administering any arboricultural technique to the garden. Some refreshers on pruning are listed in this report as several improper pruning cuts were observed on trees in the garden. Pruning trees properly can reduce abiotic disorders, biotic disorders, defects, hazards, and improve their appearance. ANSI A300 (Part 1) – 2008, the consensus standard to which most of the green industry adheres, defines pruning as the selective removal of plant parts

to meet specific goals and objectives. Maymont should adhere to these standards and distribute a copy of the publication to every horticulturalist on site.

Objectives for pruning at Maymont should be established before the job begins, and each plant's individual pruning needs should be referenced prior to cutting limbs. Pruning is performed for several reasons. Among these reasons are to clean out dead parts, thin the canopy, raise the canopy for clearance, decrease the height of the tree, and to correct defects in the trees architecture from abiotic influences (e.g. weather). The guiding principle of pruning is to provide the tree with a solid structure, as free from defects as possible.

Timing of pruning can vary throughout the year, depending on the desired effects and species limitations. Bleeding and pests can be a concern for several tree species, and pruning these should always be avoided during the growing season. The best time to prune trees is generally during the dormant season when the tree will not be as stressed from wounding. However, most sources concur that pruning should be performed any time during the year if the benefits outweigh the risks, as they would with a personal injury hazard for example. Maymont is a public park and should pay close attention to pruning limbs that might lead to personal injury liability.

Circumstantial constraints (tree age, health, vitality; species tolerance, susceptibility to pests, undesirable responses to pruning-sprouting and bleeding) always play a role in decision making in regards to pruning. Deciduous trees are better pruned

during the winter when defects can be easily spotted because there is no foliage to hide structural defects. Winter pruning also reduces associated pest problemsn since the pests are not physiologically active and the sap will not flow from the wounds. Certain summer months should be avoided on any species if they have an environmentally specific disease cues. Do not prune trees as they are expanding in early spring, especially if they are known to be previously stressed because they will need all the foliage possible to recover. Flowering times of plants can be worked into pruning plans to allow for maximum aesthetic appeal.

All pruning cuts should be made with the utmost care and attention to the health of the plant. While pruning can improve a plant's health and vitality if executed properly, if executed improperly, it can be extremely detrimental. Sterility in tool care and maintenance is of the utmost importance for any pruning activity. Sterile techniques maximize the plant's ability to compartmentalize the wound and aid in the natural defense process.

Several types of pruning cuts can be made including removal, reduction, and heading cuts. Removal cuts remove braches from the point of origin at the trunk or the parent stem. A properly executed collar cut should be made at an angle that is suitable in location with the branch collar and the branch bark ridge. These cuts should never be made flush with the stem or left as a stub. Reduction cuts reduce partially dead branches back to living lateral branches that will assume apical dominance. Heading cuts are made on stems that can be cut back to a bud that is on wood two years or younger.

The standard pruning types used on landscape trees as defined by ANSI A300 are as follows:

Clean: selective pruning to remove dead, diseased, or broken branches. Cleaning should be the primary method of pruning before any other removals are considered.

Thin: selective pruning to reduce the density of live branches.

Raise: selective pruning to provide vertical clearance (i.e. clearing sidewalks, driveways, and trails).

Reduce: selective pruning to decrease height or spread.

Pruning dose should be administered in the appropriate amount to meet the desired objective. However, as a rule of thumb, no tree should be reduced past 25% of the total canopy. Because pruning depletes carbohydrate reserves in the plant tissue, the minimum number of branches should be removed to accomplish the objective. Removing excessive branches past 25% of the total canopy can reduce the tree's ability to photosynthesize and replenish its energy reserves in the biomass. Adventitious sprouts should be removed throughout the growing season as needed because these "water sprouts" can lead to poor tree structure.

Management Recommendations for Key Plantings

The inventory revealed several aspects of the garden's vegetation that need work. Examples include an abundance of one cultivar, a special need of a species, or the need to intensively manage a planting. The Japanese garden has several plant groups that need management plans including the bald cypress groves, hinoki false cypress

(*Chamaecyparis obtusa* (Siebold & Zucc.) Siebold & Zucc. ex Endl.), 'Yoshino' Japanese cedar, Japanese maple, bamboo, wax myrtle (*Morella cerifera* (L.) Small), sweetgum, osmanthus (*Osmanthus* spp.), and pines (*Pinus* spp.).

Bald Cypress

The bald cypress groves include three areas within the garden. The first area is by the eastern edge of the Koi fishpond. The second area is to the east of the walk by the first grove, and the final grove is near the west service entrance of the pond. The plantings were installed at different times, but require similar care. All the groves have "wet feet" and beautiful "knees". They serve as a great species to prevent erosion and their care is of the utmost importance. This species makes its best statement in groves (Dirr 1997) and they are planted in this garden as such. The tall, columnar shape of the trees adds character and beauty throughout the garden.

The first grove along the bank was installed in 1980 and included 21 bald cypress trees. These trees have grown significantly over the last 28 years and are quite large. Management needs for the grove include a reduction of the limbs of up to six feet to prevent children from climbing the trees and potentially getting hurt. The grove had sufficient sand in the soil to prevent surface erosion, and the trees had very few structural/health issues. A small tree found here needs removing due to its poor growth rate and lack of overall vigor. This tree stuck out in the grove and it took away from the uniformity of the planting.

The second grove that needs management is the grove to the east of the walk around the east side of the pond. This grove was planted in 1991 to compliment the grove next to it. Donations were made to Maymont to fund this planting and this makes it extremely important because donors like to see that their donated trees are being cared for properly. Maymont has a policy that donated trees are to be replaced if they die, and money can be saved by caring for them properly in the first place. Several trees looked like they had been placed too close together, and a selective thinning of the grove in five years may make the walk through that end of the garden more appealing. Bald cypress groves are designed to allow visitors to wander through a false wilderness (Schaarschmidt-Richter *et al.* 1979). Also, several branches need removal to prevent small children from climbing and becoming liabilities. More sand in the amount of 1–2 inches should be added to this grove as the soil here lacks the proper composition for bald cypress.

The final bald cypress grove that should be tended to is the grove at the west service entrance. This grove was planted in November 2003 and is still establishing itself. This species is a good choice here due to the constant flooding from the canal and consistently high water table. The trees seem healthy and do not require pruning as most of their height is below 9 feet. Sand could be added to the soil to prevent puddling around the bases and make for a more aesthetically pleasing grove. Grasses around the base should be kept at a minimum height and these trees should be inspected often for disease/cultural problems as the grove is still developing.

Hinoki False Cypress

Hinoki false cypresses are among the slowest growing woody plants in the Japanese garden. These plants were donated by the Garden Club of Virginia in 1997. Upon completion of the Japanese garden's Grotto land feature, they were moved there to accent the front of the stalactites. The grove is well suited for the spot, but often neglected due to its tucked-away location. Weeding out many invasive species is a must and should be done on a biannual basis. A late spring weeding and a summer weeding should be sufficient unless managers see an increase in weeds from the current population. Mulching would help keep the population down, but the root collars need to be excavated first as they are currently buried. In 2006, when the trees were moved to the front of the Grotto, they were planted too low. Only one specimen needed to be removed due to a heavy infestation of spider mites.

'Yoshino' Japanese Cedar

Directly across the pond from the hinoki false cypresses are the 'Yoshino' Japanese cedars. These evergreens are a variety of Japanese cedar that exhibits a formal pattern of growth resulting in an evenly shaped shrub. In the garden they serve as an excellent screen when planted as a grouping (Dirr 1997) and hide the fence found along the south gate. Although the cedars are in good condition, they could be better managed to provide long lasting beauty and functionality.

Mulching the group planting of cedars would go a long way towards healthier specimens. Right now, the group is planted in grass and constantly being mowed around

during the summer. Weed trimmers are used around the bases of these shrubs and can damage the bark. Some plants show signs of minor damage that could be prevented by mulching and weeding by hand. Mulch would also provide organic material for the plants through time and provide for a better soil structure, as they grow best in a moist, well-drained, acidic soil (Dirr 1997). Edging this bed would be a good idea to prevent the grass from growing back around the bases and provide a definite line for the eye to follow. While the bed is being edged, time should be taken to excavate root collars as the plants seem to have been planted low when they were installed. The line of the bed should be curved, following the practices used in Japanese gardening.

Japanese Maple

Japanese maples in the garden are Maymont's premier species for ornamental value. Several cultivars of are found in the Japanese garden including 'Kilarney', 'Oregon Sunset', 'Autumn Fire', 'Waterfall', and several others. The heights of these trees range from eight feet to over twenty feet. Most of the specimens found here are in good condition. However, they could benefit from structural pruning and mulching. Mulching with pine bark would be beneficial because it would add to the acidity of the soil and provide sufficient fertilization throughout time. Placing cultivar names on plaques to show the public the many varieties of Japanese maples that are commercially available would be beneficial.

Japanese maples should be pruned in the late winter to avoid bleeding of sap. As spring approaches, and sap starts to flow, pruning maples can become hazardous to the trees (Dirr 1998). Gushing sap may cause borer insect problems, loss of vitality, and

attract fungi. An appropriate time to prune the plants in the garden is from late November after the leaves drop to early January. A bonsai-style pruning is preferred as this tree looks best when it is of a smaller stature.

Japanese maples should be watered during extreme drought to prevent serious damage. Also, shade from the afternoon sun is preferred as this can damage a tree similar to drought stress. If proper cultural care is taken, these trees are remarkably free of insect and disease issues (Vertrees and Gregory 2001). Japanese maples provide an historical look for the entire Japanese garden and will only grow to be more beautiful with age.

Bamboo

Bamboo was not a species inventoried in this project, although this grass species has taken over a large portion of the north side of the garden. Due to its invasive nature, the bamboo requires management since bamboo can ruin a garden if left unchecked. Maintenance includes removal of canes, treating with an appropriate herbicide, and periodically removing rhizomes if they encroach on walkways. Currently, large sections of the bamboo are spreading vigorously throughout the Japanese garden.

Recently, an old trail used by Mrs. Dooley was uncovered and dug out to remove bamboo that had taken over the path. The trail was less than 100 yards long, yet took almost five weeks to excavate. This area's lack of attention should show managers the cost of not paying attention to the management of bamboo. The bamboo was probably planted by the Dooleys because of its elegant leaf structure and its common use in Japanese gardens (Saito and Wada 1964). Bamboo removed from the garden can be used

to make fences to keep animals and visitors out of new planting areas (Shigemori and Newsom 1960). A simple *Kinkakujii* fence made from three large bamboo canes can be fastened together and would be complimented nicely with S*hishi-odoshi* (Yoshikawa 1990), which are bamboo noise makers that deter animals like the deer that frequent the garden.

Wax Myrtle

Wax myrtle is a shrub used as a screen for the fencing along the southwest corner, and it should be cared for properly to reduce re-planting costs. Two wax myrtles were recently replaced due to neglect. The area of placement is functional, but can lead to neglect due to the hedge being tucked away from sight. Pruning of dead wood is needed and a healthy mulching is certainly required. Edging for the bed should go all the way to the fence as this area is still in the root zone of the plants. Cheap hardwood mulch can be used here since the public seldom view this area due to its location away from the main paths.

Sweetgum

Sweetgum are found scattered throughout the Japanese garden. These trees are messy because they drop fruit throughout the fall and winter, requiring heavy cleanup. As these trees die out, it is recommended to replace them with different species. With an abundance of trees to choose from, the sweetgum seems like a bad choice for an exotic garden. Removing these trees might be the best option for the garden. These trees are in good shape, but many require structural pruning and their size limits management ability.

Maymont does not currently have a climbing arborist on staff and this work has to be contracted. A smaller stature species may be more suitable to properly manage instead of carrying on the cultivation of the large, messy, and unattractive sweetgum.

Osmanthus

A 17 specimen osmanthuus grove is located on the southwest side of the garden and deserves specific mentioning. Both Fortune's osmanthus (*Osmanthus* × *fortunei*) and sweet osmanthus (*Osmanthus fragrans*) occur in this grove. Their fragrance is a real treat for visitors and their care should be a priority of management. Right now, they are relatively neglected with no fertilizer, mulch, or structural pruning.

A well-mulched bed would bring about uniformity in the planting and reduce the use of weed eaters around the base. Mulching would also provide protection from the cold and pruning back in the spring would eliminate the appearance of cold damage on the shoots. Care should be taken to wait until after they flower to not reduce the abundant fragrant blooms. Cut the shoots back to stems to hide pruning wounds (Brickell and Joyce 1996). Right now, the grove is next to the river, which provides an excellent microclimate for them to thrive. They have the room to grow to their fullest potential of 25 feet if left unchecked (Dirr 1998), but this grove should be maintained at a height no more than 10 feet.

Pines

Pine varieties in this garden include Korean, Japanese, Virginia, loblolly and white pine (*Pinus strobus* L.). Managing these pine varieties require similar care and they are among the easiest trees in the garden to cultivate. Virginia pines should be removed due to the old cones not abscising and detracting from the aesthetics. The Korean pines require bamboo removal throughout and should be pruned to remove deadwood. The loblolly and white pines do not require mulching as these trees will grow almost anywhere. Trees should be removed when damaged and replaced if necessary.

Conclusion

Maymont's Japanese garden inventory revealed several aspects that needed work and several areas that were currently being properly managed. Management needs of the garden that were revealed included mulching, pruning, and removal of trees. Species diversity was closely examined. The five most abundant species were bald cypress (18.6%), 'Yoshino' Japanese cedar (10.8%), Japanese maple (9.9%), loblolly pine (8.1%), and sweetgum (4.5%). Overall, the Japanese garden contained 333 woody plants; 286 of those were trees. There was a good diversity of plant material, including 48 different species of woody plants.

DBH measurements of the trees revealed that this is a younger garden as the majority of the trees fell in the 0.5–10 inch diameter range. While there were some larger trees, the distribution was skewed to the smaller size classes, indicating the young age of

the urban forest. This garden is much younger than the rest of the park where some trees are found in excess of 80 inches DBH.

The inventory revealed that 37 trees needed pruning; evidence of past improper pruning was noted. Also, the inventory revealed that 113 trees and shrubs needed mulching, 38 needed removal, 3 needed fertilizing, 4 needed vines removed, and 4 needed pest management. If these items of garden maintenance are addressed, managers and visitors alike will have a more diverse and beautiful garden to enjoy. A major issue that needs addressing is one that most horticulturalists find difficult – proper pruning techniques.

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VITA

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APPENDIX

A1. Data Collection Protocol for GPS Unit

A protocol for data collection using the handheld Trimble Geo XT was developed. Ideally, this protocol will serve as a guide throughout the years of how trees attributes will be recorded. Due to Maymont's high turnover rate for employees, this was seen as a necessity to facilitate training and make data collection an easy task to learn. The protocol was worked out with test files before any field work could be performed.

Equipment procedures for data transfer were also needed and are included in this paper. A co-worker at Maymont was the final test for this protocol and once they figured out how to use the GPS based on these instructions, it was finalized. The protocol for data collection on the Trimble GeoExplorer 2005 is as follows:

1. Turn on the handheld device with the green button and open TerraSync under START menu in windows operating system (touchscreen).
2. MAYMONT TREES comes up as the default dictionary, if it doesn't, select it from the menu.
3. Set up current day's collection under the date of the day recorded, no dashes, no spaces (e.g. 12202008 is December 20th 2008). Each file needs to be named after the day in case there is a glitch in the collection file. This way, not all is lost.
4. Once the program is open, go to tree to be logged in and click CREATE function on screen.
5. If there are sufficient satellites, the pen icon will start beeping and recording points automatically. The satellite icon must be locked and the airplane icon must be present at

the top of the page. Note – at least four satellites are needed to collect a sub-meter location.

6. If no satellites are up, you can check the schedule of the satellites and their positions by pressing STATUS on the drop box in the top left hand corner of the screen. SKYPLOT gives you the location of the satellites and PLAN lets the user see what time of day is best to take readings with a histograph (2, 4, 6, and 12 hr. windows available under options).

7. Once a point is collected with 30 or more pen flashes, the position is locked and ready. Pause allows the user to pause the satellite and can be used to move away briefly and come back to the position when ready. Hit OK button to store attributes and geographic location automatically. Note – no saving needed as data is stored in GPS with OK button.

8. Start process over with CREATE button for new trees.

9. Hit CLOSE function when data collection is complete and press small X button at top right hand corner to exit TerraSync software.

Offsetting Data Points:

Offsetting a data point is used to log in hard to reach trees with no satellite signal. The user can stand where there is a satellite signal and measure the distance to the tree with corrections for directional bearing (0-360 degrees).

To Offset:

1. Go to OPTIONS under drop box in creating data points feature.

2. Go to Bearing-Distance option.

3. Measure directional bearing to tree with a handheld compass (0–360°), with 0° being due North and 180° being due South.

4. Measure distance to tree in feet and place in horizontal distance attribute.

5. No vertical corrections needed over short distances and slight elevation changes.

6. Hit OK and offset is complete.

To Update Existing Files:

This can be useful to update files if satellite windows are crucial and the data needs to be edited at a base station.

1. Go to File Manager under the drop box. Note – make sure no files are open.

2. Go to Update Files under drop box.

3. Double-tap on file with stylus.

4. Find tree or point that needs editing and double click to open.

5. Edit and Click OK button to save.

This protocol can be used as a guide to collect data points and update the Maymont tree inventory. Advanced functions can be referenced in the Trimble handheld Geo XT manual.

A2. Tabular List of Tree Inventory Data

Common Name	Botanical Name	DBH[1]	Condition	X-Coordinate[2]	Y-Coordinate
American beech	Fagus grandifolia	36.0	Fair	281259.962584	4156826.99590
American beech	Fagus grandifolia	36.0	Fair	281259.605767	4156833.56592
American beech	Fagus grandifolia	31.0	Good	281279.078280	4156822.41680
American boxwood	Buxus sempervirens	3.0	Good	281172.966945	4156872.12201
American holly	Ilex opaca	15.0	Fair	281127.946400	4156856.86586
American holly	Ilex opaca	19.0	Fair	281231.232328	4156853.04902
American holly	Ilex opaca	21.0	Fair	281274.833373	4156836.28759
American holly	Ilex opaca	23.0	Fair	281243.046958	4156838.86964
American holly	Ilex opaca	4.5	Good	281253.882892	4156833.88182
American holly	Ilex opaca	13.0	Good	281140.546948	4156858.23446
American sycamore	Platanus occidentalis	43.0	Fair	281071.288835	4156881.06006
American sycamore	Platanus occidentalis	37.0	Good	281098.722016	4156860.71609
American sycamore	Platanus occidentalis	33.0	Poor	281144.876859	4156835.75706
Aucuba	Aucuba japonica	N/A[3]	Fair	281101.203576	4156895.92730
Bald cypress	Taxodium distichum	1.0	Fair	281090.608657	4156867.88911
Bald cypress	Taxodium distichum	4.0	Fair	281250.280069	4156796.75768
Bald cypress	Taxodium distichum	4.5	Fair	281245.936465	4156788.73596
Bald cypress	Taxodium distichum	4.5	Fair	281251.036322	4156795.82845
Bald cypress	Taxodium distichum	4.5	Fair	281252.801224	4156801.51231
Bald cypress	Taxodium distichum	5.0	Fair	281245.760889	4156792.50584
Bald cypress	Taxodium distichum	5.0	Fair	281247.093342	4156797.98933
Bald cypress	Taxodium distichum	5.0	Fair	281250.988322	4156801.89077

Common Name	Botanical Name	DBH[1]	Condition	X-Coordinate[2]	Y-Coordinate
Bald cypress	Taxodium distichum	5.0	Fair	281257.833460	4156807.69779
Bald cypress	Taxodium distichum	5.5	Fair	281240.586723	4156784.37391
Bald cypress	Taxodium distichum	5.5	Fair	281252.968485	4156798.55228
Bald cypress	Taxodium distichum	6.0	Fair	281245.494333	4156802.13267
Bald cypress	Taxodium distichum	6.0	Fair	281247.402623	4156791.17016
Bald cypress	Taxodium distichum	6.0	Fair	281250.974634	4156798.96742
Bald cypress	Taxodium distichum	6.5	Fair	281243.565758	4156785.58379
Bald cypress	Taxodium distichum	7.5	Fair	281246.535863	4156786.27293
Bald cypress	Taxodium distichum	8.0	Fair	281246.446722	4156804.70487
Bald cypress	Taxodium distichum	10.0	Fair	281243.930086	4156802.70833
Bald cypress	Taxodium distichum	11.0	Fair	281243.646285	4156803.49680
Bald cypress	Taxodium distichum	0.5	Good	281098.421220	4156851.85025
Bald cypress	Taxodium distichum	1.0	Good	281095.226758	4156858.09133
Bald cypress	Taxodium distichum	1.5	Good	281083.642656	4156862.85820
Bald cypress	Taxodium distichum	2.0	Good	281089.355304	4156865.50173
Bald cypress	Taxodium distichum	2.5	Good	281086.054498	4156860.95296
Bald cypress	Taxodium distichum	2.5	Good	281087.783944	4156865.63607
Bald cypress	Taxodium distichum	2.5	Good	281091.733417	4156859.86848
Bald cypress	Taxodium distichum	3.0	Good	281088.267414	4156861.73383
Bald cypress	Taxodium distichum	5.0	Good	281243.191528	4156794.71483
Bald cypress	Taxodium distichum	5.0	Good	281255.283575	4156805.81548
Bald cypress	Taxodium distichum	5.5	Good	281257.759020	4156797.48183
Bald cypress	Taxodium distichum	6.5	Good	281255.715377	4156802.46395

Common Name	Botanical Name	DBH[1]	Condition	X-Coordinate[2]	Y-Coordinate
Bald cypress	Taxodium distichum	7.0	Good	281248.488421	4156794.67373
Bald cypress	Taxodium distichum	7.0	Good	281251.525849	4156795.26747
Bald cypress	Taxodium distichum	7.5	Good	281253.101554	4156798.48445
Bald cypress	Taxodium distichum	8.0	Good	281243.212183	4156786.60893
Bald cypress	Taxodium distichum	8.0	Good	281248.200454	4156792.80030
Bald cypress	Taxodium distichum	8.0	Good	281248.051304	4156794.82708
Bald cypress	Taxodium distichum	8.0	Good	281250.893916	4156804.51404
Bald cypress	Taxodium distichum	9.0	Good	281242.589199	4156783.75896
Bald cypress	Taxodium distichum	9.0	Good	281250.525552	4156802.02760
Bald cypress	Taxodium distichum	10.0	Good	281236.439845	4156803.22068
Bald cypress	Taxodium distichum	10.0	Good	281247.870848	4156802.21301
Bald cypress	Taxodium distichum	10.0	Good	281255.841643	4156806.59516
Bald cypress	Taxodium distichum	11.0	Good	281236.560915	4156795.47819
Bald cypress	Taxodium distichum	11.0	Good	281241.447446	4156783.16113
Bald cypress	Taxodium distichum	13.0	Good	281239.309410	4156795.56471
Bald cypress	Taxodium distichum	13.0	Good	281241.548057	4156792.70138
Bald cypress	Taxodium distichum	13.0	Good	281245.324719	4156810.25451
Bald cypress	Taxodium distichum	14.0	Good	281231.805464	4156794.53676
Bald cypress	Taxodium distichum	14.0	Good	281237.233886	4156794.09252
Bald cypress	Taxodium distichum	14.0	Good	281247.244418	4156807.88360
Bald cypress	Taxodium distichum	18.0	Good	281233.755863	4156789.36126
Bald cypress	Taxodium distichum	20.0	Good	281233.408271	4156789.13738
Bald cypress	Taxodium distichum	20.0	Good	281239.813863	4156796.37666

Common Name	Botanical Name	DBH[1]	Condition	X-Coordinate[2]	Y-Coordinate
Bald cypress	Taxodium distichum	21.0	Good	281234.091103	4156785.82035
Bald cypress	Taxodium distichum	23.0	Good	281229.823723	4156794.46068
Bald cypress	Taxodium distichum	24.0	Good	281230.787469	4156783.14290
Bald cypress	Taxodium distichum	0.5	Poor	281244.453024	4156771.14855
Bald cypress	Taxodium distichum	1.0	Poor	281245.371577	4156768.32244
Bald cypress	Taxodium distichum	2.0	Poor	281241.443170	4156788.37928
Bald cypress	Taxodium distichum	4.0	Poor	281238.728662	4156798.83934
Bald cypress	Taxodium distichum	4.5	Poor	281243.785972	4156788.31194
Black oak	Quercus velutina	32.0	Good	281186.137073	4156886.96423
Chinese holly	Ilex cornuta 'Rotunda'	N/A	Good	281199.508445	4156857.16216
Eastern redcedar	Juniperus virginiana	18.0	Good	281144.160196	4156870.96989
Eastern redcedar	Juniperus virginiana	21.0	Good	281253.319821	4156822.26226
Flowering apricot	Prunus mume	4.5	Fair	281151.242732	4156863.25211
Flowering apricot	Prunus mume	3.0	Poor	281144.666728	4156864.03777
Flowering dogwood	Cornus florida	2.0	Fair	281189.065569	4156887.47868
Flowering dogwood	Cornus florida	2.0	Fair	281189.958449	4156883.40053
Flowering dogwood	Cornus florida	2.5	Fair	281188.278960	4156884.53378
Flowering dogwood	Cornus florida	6.0	Fair	281102.944810	4156875.67420
Flowering dogwood	Cornus florida	1.7	Good	281116.491860	4156857.64647
Flowering dogwood	Cornus florida	3.0	Good	281142.381195	4156858.59607
Flowering dogwood	Cornus florida	3.5	Good	281188.271069	4156883.56123
Flowering dogwood	Cornus florida	4.0	Good	281137.334520	4156869.27972
Flowering dogwood	Cornus florida	4.0	Good	281191.036698	4156884.85012

Common Name	Botanical Name	DBH[1]	Condition	X-Coordinate[2]	Y-Coordinate
Flowering dogwood	Cornus florida	4.0	Good	281114.519040	4156868.84877
Flowering dogwood	Cornus florida	5.0	Good	281256.091596	4156829.43336
Flowering dogwood	Cornus florida	5.0	Good	281178.050996	4156890.08092
Flowering dogwood	Cornus florida	5.5	Good	281177.986788	4156887.23030
Flowering dogwood	Cornus florida	7.5	Good	281183.555983	4156896.74421
Fortune's osmanthus	Osmanthus x fortunei	N/A	Good	281228.126011	4156779.07037
Fortune's osmanthus	Osmanthus x fortunei	N/A	Good	281230.156940	4156779.26723
Fortune's osmanthus	Osmanthus x fortunei	N/A	Good	281236.348828	4156778.08424
Fortune's osmanthus	Osmanthus x fortunei	N/A	Good	281238.136455	4156778.36477
Fortune's osmanthus	Osmanthus x fortunei	N/A	Good	281241.751175	4156777.77616
Fortune's osmanthus	Osmanthus x fortunei	N/A	Good	281242.502636	4156779.03480
Fortune's osmanthus	Osmanthus x fortunei	N/A	Good	281236.756935	4156775.19349
Fortune's osmanthus	Osmanthus x fortunei	N/A	Good	281239.923537	4156775.12947
Fortune's osmanthus	Osmanthus x fortunei	N/A	Good	281242.537924	4156775.85837
Fortune's osmanthus	Osmanthus x fortunei	N/A	Good	281215.820354	4156787.49361
Glossy abelia	Abelia x grandiflora	N/A	Good	281146.332114	4156843.15245
Hinoki false cypress	Chamaecyparis obtusa 'Nana'	0.5	Good	281201.939410	4156880.33527
Hinoki false cypress	Chamaecyparis obtusa 'Nana'	0.5	Good	281202.692065	4156881.71660
Hinoki false cypress	Chamaecyparis obtusa 'Nana'	0.5	Good	281203.693021	4156881.97697
Hinoki false cypress	Chamaecyparis obtusa 'Nana'	0.5	Good	281205.499502	4156879.02113
Hinoki false cypress	Chamaecyparis obtusa 'Nana'	0.5	Good	281207.035184	4156879.69420
Hinoki false cypress	Chamaecyparis obtusa 'Nana'	0.5	Good	281208.377785	4156879.88631
Hinoki false cypress	Chamaecyparis obtusa 'Nana'	0.5	Good	281211.414869	4156879.64343

Common Name	Botanical Name	DBH[1]	Condition	X-Coordinate[2]	Y-Coordinate
Hinoki false cypress	Chamaecyparis obtusa 'Nana'	0.5	Good	281211.709063	4156878.36422
Hinoki false cypress	Chamaecyparis obtusa 'Nana'	0.5	Good	281212.191227	4156876.40108
Hinoki false cypress	Chamaecyparis obtusa 'Nana'	1.0	Good	281209.496564	4156878.14224
Hinoki false cypress	Chamaecyparis obtusa	10.0	Good	281136.931048	4156873.66841
Hinoki false cypress	Chamaecyparis obtusa	11.0	Good	281142.825811	4156874.99764
Hinoki false cypress	Chamaecyparis obtusa	16.0	Good	281114.563088	4156898.94671
Hinoki false cypress	Chamaecyparis obtusa	22.0	Good	281121.449982	4156904.98538
Hinoki false cypress	Chamaecyparis obtusa 'Nana'	0.5	Poor	281211.590426	4156876.99830
Hophornbeam	Ostrya virginiana	6.0	Good	281249.355079	4156827.53290
Hortensia	Hydrangea macrophylla	N/A	Fair	281168.998657	4156876.31833
Japanese black pine	Pinus thunbergii 'Thunderbird'	1.0	Fair	281203.597736	4156855.36003
Japanese black pine	Pinus thunbergii 'Thunderbird'	2.0	Good	281211.445030	4156834.13767
Japanese black pine	Pinus thunbergii 'Thunderbird'	4.0	Good	281227.127487	4156823.14570
Japanese black pine	Pinus thunbergii	5.5	Good	281209.822452	4156849.34949
Japanese black pine	Pinus thunbergii	6.0	Good	281205.393485	4156841.12329
Japanese camellia	Camellia japonica	2.0	Good	281080.825085	4156889.23306
Japanese camellia	Camellia japonica	3.0	Good	281081.056154	4156886.80390
Japanese cedar	Cryptomeria japonica	6.5	Good	281115.275150	4156850.78300
Japanese holly	Ilex crenata	N/A	Good	281126.504878	4156897.80088
Japanese holly	Ilex crenata	N/A	Good	281125.316730	4156892.31077
Japanese holly	Ilex crenata	N/A	Good	281134.340598	4156891.66754
Japanese holly	Ilex crenata	N/A	Good	281134.520801	4156891.16080
Japanese holly	Ilex crenata	N/A	Good	281133.807457	4156891.41263

Common Name	Botanical Name	DBH[1]	Condition	X-Coordinate[2]	Y-Coordinate
Japanese holly	Ilex crenata	N/A	Good	281126.914350	4156893.89623
Japanese holly	Ilex crenata	N/A	Good	281126.274382	4156892.76307
Japanese holly	Ilex crenata	N/A	Good	281126.620501	4156891.67148
Japanese holly	Ilex crenata	N/A	Good	281128.342389	4156889.19958
Japanese holly	Ilex crenata	N/A	Good	281128.229036	4156888.05326
Japanese holly	Ilex crenata	N/A	Good	281128.481290	4156886.55451
Japanese maple	Acer palmatum	7.0	Fair	281218.088818	4156822.20843
Japanese maple	Acer palmatum	13.0	Fair	281157.558408	4156836.08219
Japanese maple	Acer palmatum	20.0	Fair	281113.962005	4156888.84662
Japanese maple	Acer palmatum	1.2	Good	281136.277168	4156901.93874
Japanese maple	Acer palmatum 'Dissectum'	3.0	Good	281106.567083	4156871.29682
Japanese maple	Acer palmatum	3.5	Good	281229.631722	4156861.07961
Japanese maple	Acer palmatum	4.0	Good	281187.085901	4156863.52743
Japanese maple	Acer palmatum	6.0	Good	281201.549127	4156847.28223
Japanese maple	Acer palmatum	6.0	Good	281233.497079	4156811.12482
Japanese maple	Acer palmatum	6.0	Good	281189.466649	4156877.90210
Japanese maple	Acer palmatum	7.0	Good	281226.540349	4156814.88391
Japanese maple	Acer palmatum	8.0	Good	281129.464104	4156857.10146
Japanese maple	Acer palmatum	8.8	Good	281104.751316	4156897.78542
Japanese maple	Acer palmatum	9.0	Good	281172.908735	4156879.99710
Japanese maple	Acer palmatum	10.0	Good	281107.983653	4156864.72057
Japanese maple	Acer palmatum	11.0	Good	281134.357418	4156906.91797
Japanese maple	Acer palmatum	12.0	Good	281129.735822	4156877.60565

Common Name	Botanical Name	DBH[1]	Condition	X-Coordinate[2]	Y-Coordinate
Japanese maple	Acer palmatum	13.0	Good	281106.090349	4156901.74605
Japanese maple	Acer palmatum	16.0	Good	281116.144006	4156906.89719
Japanese maple	Acer palmatum	27.0	Good	281163.235161	4156832.40581
Japanese maple	Acer palmatum	1.0	Poor	281152.367168	4156900.51917
Japanese maple 'Bonfire'	Acer palmatum 'Bonfire'	6.0	Fair	281150.552382	4156840.60679
Japanese maple 'Fireglow'	Acer palmatum 'Fireglow'	1.5	Good	281126.640683	4156897.89964
Japanese maple 'Green Filigree'	Acer palmatum 'Green Filigree'	0.4	Good	281077.435622	4156889.21421
Japanese maple 'Green Hornet'	Acer palmatum 'Green Hornet'	2.5	Good	281158.343945	4156860.95548
Japanese maple 'Kilarny'	Acer palmatum 'Kilarny'	3.0	Good	281074.475707	4156886.50073
Japanese maple 'Moonfire'	Acer palmatum 'Moonfire'	7.0	Good	281224.538089	4156831.46171
Japanese maple 'Oregon Sunset'	Acer palmatum 'Oregon Sunset'	3.5	Good	281219.719285	4156794.56561
Japanese maple 'Sharps Pygmy'	Acer palmatum 'Sharps Pygmy'	1.0	Good	281182.391652	4156879.00713
Japanese maple' Shishio Improved'	Acer palmatum 'Shishio Improved'	8.0	Good	281125.708309	4156915.05644
Japanese maple 'Tamuke Yama'	Acer palmatum 'Tamuke Yama'	1.5	Good	281216.340409	4156841.19983
Japanese maple 'Threadleaf'	Acer palmatum dissectum	1.0	Good	281100.502178	4156890.41300
Japanese maple 'Waterfall'	Acer palmatum 'Taki-no-gawa'	1.0	Good	281171.654992	4156849.31093
Japanese stewartia	Stewartia pseudocamellia	3.0	Good	281087.858032	4156877.86064
Japanese stewartia	Stewartia pseudocamellia	5.0	Good	281114.062544	4156868.10284
Japanese umbrella pine	Sciadopitys verticillata	4.5	Good	281073.347839	4156892.34599
Japanese white pine	Pinus parviflora	13.0	Good	281132.631841	4156884.80139
Katsura tree	Cercidiphyllum japonicum	7.0	Fair	281148.969114	4156847.65736
Katsura tree	Cercidiphyllum japonicum	23.0	Good	281161.359778	4156852.11503
Korean evodia	Evodia daniellii	5.0	Good	281086.960468	4156901.51388

Common Name	Botanical Name	DBH[1]	Condition	X-Coordinate[2]	Y-Coordinate
Korean pine	Pinus koraiensis	7.2	Fair	281165.909405	4156901.99824
Korean pine	Pinus koraiensis	7.0	Good	281169.319026	4156897.63439
Korean pine	Pinus koraiensis	7.0	Good	281159.631676	4156903.81680
Korean pine	Pinus koraiensis	7.5	Good	281158.620825	4156902.86900
Korean pine	Pinus koraiensis	9.5	Good	281164.609995	4156899.10294
Korean pine	Pinus koraiensis	4.0	Poor	281160.955865	4156893.57232
Korean pine	Pinus koraiensis	5.0	Poor	281157.351700	4156908.71557
Korean pine	Pinus koraiensis	6.0	Poor	281158.101125	4156905.95786
Kousa dogwood	Cornus kousa	9.0	Good	281248.253113	4156806.23443
Loblolly pine	Pinus taeda	5.0	Fair	281123.487956	4156851.38895
Loblolly pine	Pinus taeda	5.3	Fair	281108.538106	4156855.27089
Loblolly pine	Pinus taeda	5.5	Fair	281103.215286	4156861.38000
Loblolly pine	Pinus taeda	6.0	Fair	281105.953162	4156856.21872
Loblolly pine	Pinus taeda	6.7	Fair	281105.053365	4156848.88926
Loblolly pine	Pinus taeda	7.5	Fair	281099.113476	4156865.24746
Loblolly pine	Pinus taeda	12.0	Fair	281129.908657	4156846.12109
Loblolly pine	Pinus taeda	14.0	Fair	281138.735678	4156846.13488
Loblolly pine	Pinus taeda	-	Fair	281067.658165	4156875.06461
Loblolly pine	Pinus taeda	5.0	Good	281100.887878	4156861.25070
Loblolly pine	Pinus taeda	6.5	Good	281080.548483	4156862.65923
Loblolly pine	Pinus taeda	7.5	Good	281118.072923	4156856.46066
Loblolly pine	Pinus taeda	9.5	Good	281110.944263	4156854.60187
Loblolly pine	Pinus taeda	11.0	Good	281107.842575	4156851.73289

Common Name	Botanical Name	DBH[1]	Condition	X-Coordinate[2]	Y-Coordinate
Loblolly pine	Pinus taeda	20.0	Good	281144.073326	4156854.57294
Loblolly pine	Pinus taeda	21.0	Good	281092.641769	4156873.24721
Loblolly pine	Pinus taeda	23.0	Good	281096.233318	4156871.28902
Loblolly pine	Pinus taeda	27.0	Good	281106.436519	4156855.66194
Loblolly pine	Pinus taeda	30.0	Good	281197.763294	4156852.98627
Loblolly pine	Pinus taeda	31.0	Good	281210.538654	4156830.51114
Loblolly pine	Pinus taeda	3.5	Poor	281106.225870	4156859.17047
Loblolly pine	Pinus taeda	5.0	Poor	281080.854354	4156869.14732
Loblolly pine	Pinus taeda	6.0	Poor	281074.562727	4156864.70579
Loblolly pine	Pinus taeda	9.0	Poor	281121.854923	4156855.66066
Loblolly pine	Pinus taeda	9.0	Poor	281077.539721	4156869.29321
Loblolly pine	Pinus taeda	10.0	Poor	281128.584152	4156846.55939
Loblolly pine	Pinus taeda	10.0	Poor	281075.308140	4156866.74500
Mahonia	Mahonia bealei	N/A	Fair	281171.248836	4156874.57345
Paperbark maple	Acer griseum	3.5	Fair	281161.599728	4156874.85941
Pignut hickory	Carya glabra	28.0	Fair	281241.654793	4156848.81499
Pignut hickory	Carya glabra	24.0	Good	281194.835513	4156884.21278
Pignut hickory	Carya glabra	41.0	Poor	281238.953628	4156861.42540
Red maple	Acer rubrum	23.0	Fair	281101.926732	4156880.03015
Red maple	Acer rubrum	21.0	Good	281139.461913	4156853.27026
Red maple	Acer rubrum	22.0	Good	281126.986743	4156847.95398
Red maple	Acer rubrum	23.0	Good	281196.150375	4156872.73058
Red maple	Acer rubrum	24.0	Good	281132.848416	4156866.62539

Common Name	Botanical Name	DBH[1]	Condition	X-Coordinate[2]	Y-Coordinate
Red maple	Acer rubrum	25.0	Good	281217.250481	4156838.36860
Red maple	Acer rubrum	26.0	Good	281148.398245	4156855.68281
Red maple	Acer Rubrum	27.0	Good	281160.289739	4156880.45824
Red oak	Quercus rubra	4.5	Good	281252.239583	4156776.04005
Redbud	Cercis canadensis	3.5	Fair	281137.681352	4156851.77745
Redbud	Cercis canadensis	5.0	Fair	281255.525941	4156822.99721
Redbud	Cercis canadensis	4.0	Poor	281268.795007	4156815.34036
River birch	Betula nigra 'Little King'	0.5	Fair	281213.333903	4156882.80111
River birch	Betula nigra 'Little King'	1.0	Fair	281209.450291	4156883.36773
River birch	Betula nigra	26.0	Poor	281263.276175	4156811.70417
Sawara false cypress	Chamaecyparis pisifera 'Filifera'	13.0	Fair	281141.231082	4156869.88102
Sawara false cypress	Chamaecyparis pisifera 'Filifera'	13.0	Good	281125.296204	4156873.15667
Shore juniper	Juniperus conferta 'Blue Pacific'	N/A	Good	281087.756445	4156894.01215
Sourwood	Oxydendrum arboreum	6.0	Poor	281073.679627	4156884.55744
Sweet osmanthus	Osmanthus fragrans	N/A	Good	281225.713812	4156779.82014
Sweet osmanthus	Osmanthus fragrans	N/A	Good	281231.631133	4156778.09993
Sweet osmanthus	Osmanthus fragrans	N/A	Good	281232.888119	4156776.99008
Sweet osmanthus	Osthmanthus fragrans	N/A	Good	281217.506730	4156785.47870
Sweet osmanthus	Osmanthus fragrans	N/A	Good	281217.356584	4156784.85680
Sweet osmanthus	Osmanthus fragrans	N/A	Good	281220.689806	4156783.25587
Sweet osmanthus	Osmanthus fragrans	N/A	Good	281224.249568	4156781.71470
Sweetgum	Liquidambar styraciflua	17.0	Fair	281146.843551	4156875.33710
Sweetgum	Liquidambar styraciflua	19.0	Fair	281170.038675	4156841.12973

Common Name	Botanical Name	DBH[1]	Condition	X-Coordinate[2]	Y-Coordinate
Sweetgum	Liquidambar styraciflua	22.0	Fair	281138.547632	4156877.94106
Sweetgum	Liquidambar styraciflua	23.0	Fair	281136.026291	4156908.38663
Sweetgum	Liquidambar styraciflua	23.0	Fair	281138.682422	4156866.82051
Sweetgum	Liquidambar styraciflua	14.0	Good	281165.175575	4156841.60420
Sweetgum	Liquidambar styraciflua	16.0	Good	281121.121307	4156877.84874
Sweetgum	Liquidambar styraciflua	21.0	Good	281115.960983	4156877.49251
Sweetgum	Liquidambar styraciflua	21.0	Good	281150.421153	4156874.87054
Sweetgum	Liquidambar styraciflua	22.0	Good	281119.159273	4156873.72179
Sweetgum	Liquidambar styraciflua	22.0	Good	281148.013865	4156874.05648
Sweetgum	liquidambar styraciflua	24.0	Good	281183.782016	4156887.28025
Sweetgum	Liquidambar styraciflua	25.0	Good	281127.034561	4156849.02506
Sweetgum	Liquidambar styraciflua	26.0	Good	281127.827094	4156877.95352
Sweetgum	Liquidambar styraciflua	39.0	Good	281206.827795	4156836.99387
Tulip poplar	Liriodendron tulipifera	29.0	Fair	281069.251300	4156890.04724
Tulip poplar	Liriodendron tulipifera	28.0	Good	281099.650491	4156895.67535
Tulip poplar	Liriodendron tulipifera	30.0	Good	281073.637642	4156889.93673
Tulip poplar	Liriodendron tulipifera	31.0	Good	281097.349887	4156891.61214
Tulip poplar	Liriodendron tulipifera	27.0	Poor	281142.139522	4156838.36767
Virginia pine	Pinus virginiana	11.0	Good	281155.078294	4156898.77394
Virginia pine	Pinus virginiana	12.0	Good	281153.268712	4156907.05675
Virginia pine	Pinus virginiana	4.0	Poor	281075.366145	4156889.28580
Virginia pine	Pinus virginiana	5.0	Poor	281150.431146	4156900.64911
Virginia pine	Pinus virginiana	8.0	Poor	281078.999462	4156893.38204

Common Name	Botanical Name	DBH[1]	Condition	X-Coordinate[2]	Y-Coordinate
Wax myrtle	Morella cerifera	N/A	Fair	281085.335829	4156855.10149
Wax myrtle	Morella cerifera	N/A	Fair	281077.201492	4156860.41059
Wax myrtle	Morella cerifera	N/A	Good	281082.100968	4156856.05687
Wax myrtle	Morella cerifera	N/A	Good	281088.225784	4156855.43906
Wax myrtle	Morella cerifera	N/A	Good	281090.979052	4156854.05199
Wax myrtle	Morella cerifera	N/A	Good	281097.194444	4156852.33242
Wax myrtle	Morella cerifera	N/A	Good	281101.389072	4156866.99810
Wax myrtle	Morella cerifera	N/A	Good	281104.782180	4156845.59920
Wax myrtle	Morella cerifera	N/A	Good	281107.238713	4156845.45167
Wax myrtle	Morella cerifera	N/A	Good	281111.315945	4156843.62547
Wax myrtle	Morella cerifera	N/A	Good	281080.686888	4156856.89967
Wax myrtle	Morella cerifera	N/A	Poor	281093.570270	4156852.42814
Wax myrtle	Morella cerifera	N/A	Poor	281099.589805	4156850.41981
Weeping cherry	Prunus subhirtella 'Pendula'	2.5	Fair	281221.272318	4156831.92405
Weeping cherry	Prunus subhirtella 'Pendula'	2.5	Fair	281223.650923	4156826.49968
Weeping cherry	Prunus subhirtella 'Pendula'	2.5	Fair	281226.381430	4156822.17769
Weeping cherry	Prunus subhirtella 'Pendula'	14.0	Good	281189.228432	4156818.55873
White ash	Fraxinus americana	25.0	Fair	281141.006780	4156838.75088
White oak	Quercus alba	28.0	Good	281102.681363	4156869.71140
Winged elm	Ulmus alata	22.0	Fair	281103.274322	4156865.42716
Winged elm	Ulmus alata	19.0	Good	281106.890102	4156860.20135
Winged elm	Ulmus alata	19.0	Good	281088.197099	4156883.04351
Winged elm	Ulmus alata	20.0	Poor	281152.165672	4156901.70170

Common Name	Botanical Name	DBH[1]	Condition	X-Coordinate[2]	Y-Coordinate
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	1.0	Fair	281188.482911	4156808.00357
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	1.0	Fair	281190.517396	4156807.49765
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	1.0	Fair	281193.253938	4156808.79166
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	1.4	Fair	281206.990771	4156795.96682
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	1.4	Fair	281209.629940	4156791.95649
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	1.5	Fair	281171.027892	4156825.62230
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	1.5	Fair	281183.195008	4156816.37760
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	1.6	Fair	281179.733108	4156818.57502
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	1.6	Fair	281185.733907	4156812.15591
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	1.7	Fair	281205.800453	4156793.37978
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	1.8	Fair	281202.630825	4156797.36802
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	1.9	Fair	281207.881785	4156793.63126
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	2.0	Fair	281170.652139	4156821.71979
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	2.0	Fair	281198.195457	4156799.92696
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	2.4	Fair	281200.692500	4156802.58169
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	1.3	Good	281193.539241	4156806.09938
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	1.7	Good	281175.404742	4156822.51750
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	2.0	Good	281184.111456	4156813.71031
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	2.0	Good	281203.235917	4156799.66522
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	2.2	Good	281179.829101	4156816.05749
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	2.2	Good	281182.222589	4156814.34372
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	2.3	Good	281166.677866	4156824.32613
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	2.3	Good	281172.891650	4156821.89857

Common Name	Botanical Name	DBH[1]	Condition	X-Coordinate[2]	Y-Coordinate
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	2.3	Good	281174.663472	4156820.22259
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	2.3	Good	281187.193107	4156810.65593
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	2.3	Good	281211.452543	4156791.16807
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	2.5	Good	281177.217484	4156820.25896
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	2.5	Good	281178.058673	4156817.17718
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	3.9	Good	281201.210542	4156799.40679
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	3.9	Good	281204.227122	4156796.44097
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	4.3	Good	281197.138524	4156802.38027
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	5.0	Good	281169.274723	4156824.08742
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	6.0	Good	281163.956218	4156825.44865
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	1.0	Poor	281189.690288	4156810.63137
Yoshino Japanese cedar	Cryptomeria japonica 'Yoshino'	3.0	Poor	281186.769677	4156814.24595

[1]DBH = diameter at breast height (4.5 ft above ground line).
[2]GPS coordinates of the plants were measured using the following coordinate system: NAD 1983 UTM 17N – meters.
[3]DBH was not measured for shrub species.