Sustainability Practices in Historic Gardens: Benchmarking Dumbarton Oaks among Local Gardens in the Washington, D.C. Area

Dumbarton Oaks Internship Report

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Introduction

Dumbarton Oaks Garden is a historic garden in Washington, D.C. designed by Beatrix Farrand in the early 20th century for Mildred and Robert Woods Bliss.[1] *Beatrix Farrand's Plant Book for Dumbarton Oaks*, originally written by Beatrix Farrand and later edited by Diane Kostial Mcguire, describes Farrand's intentions.[2] The *Plant Book* serves as a guide for understanding her rigorous garden maintenance standards, her specific garden area designs, why she designed these areas in this way, why she decided against certain designs, and how to facilitate replacing plants.[3] Mcguire describes Farrand's design as having a foundation in the classical Mediterranean garden, with influences from the garden design of Gertrude Jekyll and the garden maintenance standards of upper-class England.[4] Farrand's American interpretation incorporates plants fit for the Washington, D.C. climate, and a predominance of native American species of trees.[5] Mcguire writes that the gardens of Dumbarton Oaks are an important part "of our cultural heritage" and a physical representation of 20th century landscape architecture.[6] Thus, historical integrity is an important character of the garden today.

Maintaining historical integrity and creating a sustainable environment are important aspects of the garden's mission today, and for this reason, changes made to Dumbarton Oaks for sustainability purposes are to be understood within the limitations of the design intentions outlined by Farrand in her plant book.[7] The purpose of this research is to learn about current sustainability practices in historic gardens in the Washington, D.C. area in order to benchmark Dumbarton Oaks among these gardens. The product of this research will be recommendations for improvements to sustainability practices at Dumbarton Oaks. We have also agreed to share this report with the staff we interviewed of these gardens.

Sustainability describes the conservation of natural resources and entails the preservation of the natural environment, with one emphasis being the maintenance of ecological relationships, and for this reason, sustainability is another important character of the garden today. The topics of sustainability of interest for improvement in Dumbarton Oaks Garden that will create the body of this research include water (stormwater management, conservation), alternative equipment and fossil fuels, chemical inputs (pesticides, herbicides, fungicides, etc.), and biodiversity and habitat conservation. These topics were chosen based on an evaluation led by the Director of Gardens and Grounds of Dumbarton Oaks, Jonathan Kavalier, of the main concerns and goals of Dumbarton Oaks regarding sustainability. The staff of Dumbarton Oaks would like to reduce fossil fuel emissions and chemical use to mitigate air, water, and soil contamination, which negatively impact wildlife and human health. Water is a forefront topic of sustainability because it is a main natural resource. Dumbarton Oaks staff have undertaken major projects in recent years to conserve water and are looking to continue reducing their water use. Stormwater management is an important research topic because it addresses soil erosion prevention. Soil erosion contributes to water source contamination and landscape and habitat destruction. Out of consideration of neighbors Dumbarton Oaks Park and Montrose Park, stormwater management is important because of

[1] Beatrix Farrand, *Beatrix Farrand's Plant Book for Dumbarton Oaks*, ed. Diane Kostial McGuire. (Washington, D.C.: Dumbarton Oaks Pub, 1980).
[2] Farrand, *Plant Book.*
[3] Farrand, *Plant Book*: xii.
[4] Farrand, *Plant Book*: xi-xii.
[5] Farrand, *Plant Book*: xi.
[6] Farrand, *Plant Book*: xi.
[7] Farrand, *Plant Book.*

Dumbarton Oaks' severe topography and the subsequent stormwater runoff that disrupts these neighbors' gardens and habitats. Also, researching stormwater management is important in order to learn about potential opportunities for storing water to be used in dry weather periods, which would conserve water. Additionally, since ecological relationships define the quality and sustainability of vegetation in gardens, and since wildlife and vegetation together define a natural environment, biodiversity and habitat conservation are another important topic of this research.

Methods

For this research project, I began by collecting background information on sustainable practices at Dumbarton Oaks, specifically those falling within the categories of water (stormwater management, conservation), alternative equipment and fossil fuels, chemical inputs (pesticides, herbicides, fungicides, etc.), and biodiversity and habitat conservation. I collected this information by interviewing the gardeners and staff of Dumbarton Oaks, whose names I included in the acknowledgements section of this report. I decided to interview gardeners who specialized in areas that were relevant to my research. Walter Howell is a gardener with an interest in soil science, and an arborist, who shared a wealth of information regarding fuel use and Dumbarton Oaks' Integrative Pest Management (IPM) approach to pest and disease control and offered suggestions for sustainability improvement at Dumbarton Oaks. Marc Vedder is Dumbarton Oaks' Integrative Pest Management Specialist, an arborist, and in addition to sharing information relevant to these areas of specialty, shared information regarding the operations of the gardens, specifically those having to do with water. Kimberly Frietze is the administrative assistant of the gardens and helped me to flesh out the history of major projects done at Dumbarton Oaks, primarily those dealing with water conservation. These three staff members played an important part in my understanding of the background information relevant for this research, specifically Dumbarton Oaks' sustainability practices. Other staff members who contributed to the development of this research include Ricardo Aguilar, Melissa Brizer, Donald Mehlman, Luis Marmol, and Rigoberto Castellon, all of whom work in the gardens.

I used the questions from the American Public Garden Association's website and the background information from the Dumbarton Oaks' gardeners as references for generating questions for the interviews I later conducted with the staff of other historic and non-historic public gardens, which I limited to the region surrounding Washington, D.C., and facilitated through site visits and phone calls.[8] Choosing phone calls or site visits was based on the location of the gardens and availability of those whom I interviewed. I limited my interviews to the staff of gardens of the region surrounding Washington, D.C. because I wanted to understand the practices that would be appropriate for the weather, soil and other conditions of Dumbarton Oaks that are specific to this region.

I used the information collected from these interviews to understand the topics of sustainability that created the body of my research and to benchmark Dumbarton Oaks among these gardens. A consideration throughout these interviews was that each garden has different restrictions and missions. This research focuses on learning about the sustainability practices of historic gardens, but also explores those of non-historic gardens. The historic gardens whose staff participated in this research include Chanticleer Garden, Green Spring Gardens, Hillwood Estate, Museum and Garden, George Washington's Mount Vernon, Oatlands Historic House and Gardens, Tregaron Conservancy, and Tudor Place. The non-historic gardens whose staff participated in this research include the American University Arboretum and Gardens, Smithsonian Gardens, and the United States National Arboretum.

Another important consideration after conducting these interviews was that the information I collected may not reflect the extent of operations of those gardens, as these interviews mainly focused on the key sustainable practices of those gardens. For the purpose of making my report concise and accessible, I chose not to flesh out all the ideas provided by the staff of these other gardens and only focused on elaborating on the practices I found to have potential for implementation at Dumbarton Oaks,

[8] "Public Gardens Sustainability Index," American Public Gardens Association, accessed July 10, 2019, https://www.publicgardens.org/sustainability-index.

or practices that had been an important consideration of implementation at Dumbarton Oaks in recent years. Along with ideas from the gardeners at Dumbarton Oaks, I consolidated the information from these interviews to create a list of sustainable ideas for Dumbarton Oaks. The following discussions drew on these interviews. Specific notes can be found in the files for Dumbarton Oaks Garden.

Sustainability Practices: Dumbarton Oaks Background

1. **Water (conservation, stormwater management)**

The water use discussed in this report includes water use in main garden water systems and the maintenance of the garden and lawn areas. The main water systems of Dumbarton Oaks Garden include 12 fountains and pools, a swimming pool, changing room showers, irrigation systems, and multiple hose connections. Watering of the lawn and garden areas is facilitated with irrigation systems, sprinklers, and hand watering. Irrigation systems are timed for certain periods of the day to minimize evapotranspiration, and located in the Fountain Terrace, Rose Garden, Herbaceous Border, East and South Lawns, and North Vista. Portable oscillating sprinklers are used in other areas of the garden, such as the Cutting Garden, where plants are rotated frequently, where otherwise the frequent digging for the rotation of plantings could damage an irrigation system. Hand watering is used most frequently for isolated plantings and in smaller areas in the garden in which sprinklers or irrigation systems would be unreasonable to use or construct because of accessibility to these areas and potential overwatering that could occur as a result of the size of these areas.

Based on records from the past five years, water use at Dumbarton Oaks has decreased. A chart summarizing a record of water use at Dumbarton Oaks is included in the index section of this report, showing this general decrease in water use.[i] Recent projects intend to continue to reduce water use. An important recent water conservation project entailed making several of the fountains recirculating, thereby conserving water by preventing water overflow and runoff (which would also contribute to soil erosion) and preventing the need to resupply water into the fountains. Recirculating fountains include the Pebble Garden, Pre-Columbian, Museum, Bowling Green, Fountain Terrace, Lover's Lane Pool, Director's Residence, and the Ellipse. A complication of recirculating fountains is the accumulation of algae; however, this is being addressed with the use of UV light filters. This practice conserves water because these filters kill the algae, thereby reducing the need to frequently drain, clean, and refill the pools. These fountains are automated. Several fountains, including the Grotto, Arbor Terrace, Horeshoe, Bowling Green and Star Garden, remain non-circulating because of the limitations of their fountain structure.

In addition to this fountain work, this water conservation and stormwater management project entailed replacing the underground water supply lines, irrigation water boxes, and storm water lines, which were previously in poor condition due to old age. An important feature of this restoration was the addition of more Quick Connects, which are a type of fitting that make sprinkler and hose attachments more accessible for gardeners to connect to the water supply lines. The installation of gutters and drain inlets was also a part of this stormwater project. Other stormwater features outside of this project include catch basins, swales, and vegetative buffers. Specifically, the swales direct runoff water to the drains, and then to Rock Creek. Additionally, Curlex, an erosion control blanket, was used temporarily to prevent soil erosion on the slopes during the reestablishment of vegetation following the stormwater project. All these features generally redirect water to avoid flooding and subsequent soil erosion. Stormwater management is an important concern for the garden because soil erosion and subsequent landscape and habitat destruction in addition to water contamination have occurred in the past in the garden due to excess stormwater.

2. **Equipment (fossil fuel use, alternative sources of energy)**

All equipment at Dumbarton Oaks is diesel or gas-powered. The fuel use for this past fiscal year (July 1, 2018 to June 30, 2019) was 723.49 gallons of unleaded gas and 98.26 gallons of diesel. The equipment used at Dumbarton Oaks includes aerators, blowers, chainsaws, a generator, a leaf vacuum, a mosquito fogger, mowers, seeders, snowblowers, sprayers, tillers, trimmers, a tractor, trucks, and weed eaters. A chart of the inventory of the equipment used at Dumbarton Oaks is included in the index section

of this report.[ii] Mowers and blowers are among the most used equipment. Generally, mowing is performed on a weekly basis, and the grass is maintained at a height of 3.5 inches, and the product of cuttings from mowing is left.

An important goal for Dumbarton Oaks is to explore alternative sources of energy to gas and diesel for equipment use. Blowers and mowers are among the most used equipment, and for this reason are the larger focus of this topic. Washington, D.C. legislation is considering the removal of gas-powered blowers, which is another reason for looking into alternative equipment to gas-powered equipment. Additionally, looking into different maintenance practices such as reducing mowing frequency could be useful for Dumbarton Oaks to reduce fossil fuel emissions.

3. **Chemical Inputs (fertilizer, herbicides, pesticides)**

Dumbarton Oaks uses an Integrative Pest Management (IPM) approach to manage pests and diseases in the gardens. This approach begins with establishing an ornamental and health threshold. At Dumbarton Oaks, the acceptance of some pests, diseases, and their destruction is important for reducing the use of chemicals for pest and disease management in order to maintain healthy beneficial insects and habitat, so long as it does not disrupt the overall ornamental or health value of the garden. Using this ornamental and health threshold as a baseline, the Integrative Pest Management specialist, Marc Vedder, identifies the pests or diseases of interest and evaluates whether their destruction to the vegetation is enough to treat. The first approach to treatment is to use biological controls. The purpose of this is to have a low chemical impact, and only a high chemical impact when necessary to maintain the ornamental and health value of the garden. Additionally, adopting horticultural and maintenance practices is important to prevent the need for high chemical use. Overall, the goal of an IPM approach to pest and disease management is to reduce damage to and encourage health of habitat, wildlife, and humans through the localization, minimization, and rotation of chemical use and the choice to use chemicals of low toxicity. A list of pesticides used in the past year is included in the index section of this report.[iii]

Boxwood blight, for example, is a main disease concern for most gardens in the Washington, D.C. area, and in order to further control this disease and reduce fungicide use, Dumbarton Oaks is quarantining resistant varieties for the summer to be trialed in the fall. Boxwood blight is managed at Dumbarton Oaks by disinfecting gardening tools and clothes, cutting and pruning, quarantining, scorching, and increasing air flow to the boxwood, in addition to using fungicides.

The Rose Garden of Dumbarton Oaks is the area of highest chemical use, but plantings of disease-resistant and fungal-tolerant rose varieties intend to reduce this. Specifically, a disease of concern in the Rose Garden is Crown Gall. Galltrol is a biological input for prevention of this disease. Galltrol contains beneficial bacteria which colonize the rose crown, preventing the Crown Gall disease from establishing. Beneficial insects are also important biological controls and alternatives to chemical input for pest management in this area of the garden. For this reason, beneficial insects are encouraged within this area and throughout the garden. Companion plants and reduced spraying encourage these beneficial insect populations.

Healthy soil is an important part of pest and disease prevention and treatment. A goal of the recent Ellipse project was to enrich the soil of the Ellipse area in the garden. This project entailed incorporating compost, sand, and loam into the soil. The sand and loam create pore spaces, providing habitats for beneficial microbes. When incorporated into the soil, compost improves microbial activity, improving plant health and therefore preventing the need for high chemical input to manage diseases and pests. Minimizing chemical input is important to the mission of Dumbarton Oaks in order to maintain a healthy environment for the visitors and wildlife. As of now, Dumbarton Oaks is looking into incorporating compost, specifically compost tea, into the soil for further benefits, which include improved nutrient and water absorption.

4. **Biodiversity and Habitat Conservation**

A commensal relationship between vegetation and wildlife enriches biodiversity. Biodiversity efforts at Dumbarton Oaks include increasing the native plant population while still maintaining the historic design of Farrand. The inclusion of native vegetation is important for the proliferation of native

wildlife. This is because native vegetation and native wildlife have coevolved to benefit one another. In other words, native plants encourage native beneficial insects; beneficial insects help to prevent pests from harming the native plant by competing with these pests and prevent diseases by boosting plant immunity. Notably, these beneficial insects include pollinators, key actors in plant sustainability and proliferation. As these native insects benefit the native plants, the plants provide habitat and food for these insects, creating a commensal relationship.

Invasive species, however, can threaten the biodiversity of the garden by outcompeting native plants and thereby discouraging beneficial wildlife, specifically pollinator populations. Invasive species at Dumbarton Oaks include Chinese wisteria, English ivy, Japanese honeysuckle, periwinkle, privet, and porcelain berry. Some of these invasive species are important to the design outlined by Farrand in her *Plant Book*, and do not considerably threaten the biodiversity of the garden, depending on where they are in the garden or how they are used to maintain these design intentions.[9] Joan Chen, a former summer intern at Dumbarton Oaks working in garden and landscape studies, wrote a report on invasive species at Dumbarton Oaks, in which she addressed potential native replacements for some of these invasive species in areas in which they are not integral to Farrand's design intentions.[10] Specifically, Chen focused her research on English ivy and the rich invasive species population in Lover's Lane.[11] This research was important for discovering ways in which biodiversity could be improved by maintaining some of these invasive plants or by removing them and replacing them with native plants that fit within Farrand's design, thereby maintaining the historic nature of the garden.

An important part of biodiversity is soil quality. Biodiversity includes diversity of soil microbes. High soil quality describes soil that is uncompacted, and that has high microbial activity. Combined, these two features improve plant health and improve water absorption. The recent Ellipse project focused on reworking the soil in the Ellipse area to increase microbial activity and subsequently plant health and habitat. This project engineered soil, of which included native coastal plain soil, compost, sand, and silt. The incorporation of compost, of which was driven by Eric Fleischer, a soil scientist and horticulturist affiliated with soil improvement work at Harvard University, played an important role in increasing the microbial activity in the Ellipse area. Other important features of this project included replacing the Hornbeam trees and experimenting with cover grounds. Other important practices of soil quality improvement at Dumbarton Oaks include using plantings to avoid bare areas, which prevents the proliferation of weeds, and sending out soil samples to identify areas of compaction and ways in which soil quality and subsequently plant health can be improved.

Sustainability Practices: Learning from Other Gardens in the Washington, D.C. Area

1. Water (conservation, stormwater management)

Cisterns store stormwater to be used during periods of drought, conserving water and preventing water runoff and subsequent soil erosion. American University Arboretum and Gardens, Chanticleer Garden, Oatlands Historic House and Gardens, and Tudor Place use cisterns. Oatlands Historic House and Gardens has relied on a cistern to supply water to its garden. An interesting feature of this cistern is that it is located at a lower part of the garden, supplying water uphill, sourcing its water from a well pump. Usually, cisterns are located at higher areas of the garden to supply water downhill, but this cistern successfully stores 5,000 gallons of water and plays an integral role in the watering of the garden from a lower area. Tregaron Conservancy has an interesting strategy for storing water, in that they have partnered with a local school, at which water is collected from gutters on the school rooftop, which then feed the water into a rain barrel. This rain barrel is then transported from the school to the conservancy to

[9] Farrand, *Plant Book*.
[10] Joan Chen, "Invasive Species in the Historic Dumbarton Oaks Garden," Dumbarton Oaks Research Library and Collection, August 3, 2019, https://www.doaks.org/research/garden-landscape/summer-internship-program/2018-intern-report-chen.
[11] Chen, "Invasive Species in the Historic Dumbarton Oaks Garden."

supply water to their garden. Chanticleer Garden relies completely on a cistern to supply water to their greenhouse. This cistern stores 50,000 gallons of water. This system works such that excess greenhouse water drains and returns to the cistern, so no water is lost. Additionally, their parking lot areas drain water to another cistern, which then supplies water to areas surrounding the parking lot when needed. Tudor Place recently completed a South Lawn Cistern project. They have two cisterns located on their South Lawn, each carrying around 15,000 gallons of water for a total of 30,000 gallons of water stored. The water stored in these cisterns is collected from roof gutters, preventing sediment runoff into storm drains and reducing the impact on Chesapeake Bay watershed. A disadvantage of this system is that the cistern system switches to city water when there are 172 gallons left in the tanks, and so not all of what the cisterns store can be supplied to the garden for water use at a time.

2. **Equipment (fossil fuel use, alternative sources of energy)**

American University Arboretum and Gardens, Chanticleer Garden, Green Spring Gardens, Hillwood Estate, Museum, and Garden, Oatlands Historic House and Gardens, Smithsonian Gardens, and the United States National Arboretum have experimented with electric-powered equipment. Green Spring Gardens has trialed battery-powered equipment but found that, with the brands of equipment they used, needing multiple battery packs to supply energy for the equipment and its low horsepower made the battery-powered equipment disadvantageous despite the fossil fuel reductions this equipment promises. Oatlands Historic House and Gardens uses electric-powered equipment and has found this to be relatively successful. They mostly use the Ryobi brand, including for their weed eater and blower. For this garden, this brand is reliable and compatible with their cordless tools. Admittedly, they noted that there are better brands that they would like to investigate, however, the Ryobi brand was appropriate for the garden given the limitations of their budget. Additionally, they use the Black and Decker brand for their cordless electric hedge trimmer. They use gas-powered mowers generally but use electric mowers for slopes. These electric mowers are SunJoe 40-volt electric lawnmowers. Smithsonian Gardens uses battery-powered equipment, primarily of the brand DeWalt and Greenworks. The staff of Smithsonian Gardens recommends these brands because of their battery life and tool power. They noted that a voltage of at least 40 is necessary for the operation of the tool, and an amperage of a least 5 for the operation of the battery. Their six electric utility vehicles are John Deere Gator TE brand. They have a hybrid diesel/electric stake body Freightliner M2-106 truck. Hillwood Estate, Museum, and Garden has experienced with electric blowers of the brand Greenworks. A chart summarizing the information regarding the different types of brands noted by the staff of these gardens is included in the index section of this report.[iv]

Oatlands Historic House and Gardens adopts an interesting maintenance practice that reduces fossil fuel emissions. They adopt a quiet standard for their garden, which focuses on minimal blowing. Additionally, they maintain meadows, in which they minimally mow, reducing fuel use. The United States National Arboretum also maintains meadows, which abide by a 3-inch to 4-inch mowing standard and are typically cut once a year, except for twice a year in some other areas. Tregaron Conservancy purchases plants in bulk and from local sources to reduce truck transportation and subsequent fuel emissions. All these gardens have cultural practices that reduce fossil fuel emissions by avoiding disturbance to the natural landscape.

3. **Chemical Inputs (fertilizer, herbicides, pesticides)**

Oatlands Historic House and Gardens is working with the University of Maryland to incorporate microclover cover into their garden. This ground cover fixes atmospheric nitrogen, which can then be taken up by plants. This cover sustains in drought and prevents the need for traditional fertilizers because it manages weeds by preventing bare space, which otherwise allows for the proliferation of weeds. American University Arboretum and Gardens uses clover cover ground to achieve similar results.

Hillwood Estate, Museum and Garden manages pests and diseases with holistic plant care as an alternative to an IPM approach. This garden has an on-site passive composting program. Hillwood Estate, Museum and Garden uses vermicomposting, which entails using red wriggler worms to break down organic material. These worms must live in a moist environment of either shredded unbleached paper or

uncolored newspaper, shredded brown cardboard, wood chips, aged compost, or leaves. These worms are fed with break room waste, such as banana peels, coffee grinds, vegetable clippings, and avocado rinds. A blender grinds this break room waste before it is fed to the worms. The worms are moved to a new bin when this layer of grinded break room scraps is broken down. This worm compost, or vermicast, is then used as a microbial source for compost tea. Compost tea is a special type of compost that entails steeping compost in water.[12] An important part of this compost tea program is providing constant aeration to the compost.[13] Compost tea is a special type of compost because it can act as a soil drench and foliar spray.[14] Specifically, it enriches the nutrients for both the soil and plants and encourages the breakdown of toxins.[15] At Hillwood, vermicast and kelp meal (as a food source) are added to the aerated water to create compost tea. The goal is that this type of compost will increase microbial activity more so than traditional composts. The functional sustainability practice of this composting strategy is the return of this compost to the garden beds as a soil amendment. While most green waste is incorporated as part of Hillwood Estate, Museum and Garden's composting program, sticks and invasive vines are rather collected by Harvest, a green waste recycling and alternative energy company, for grinding into mulch and soil amendments. Green waste like leaf litter remains in their beds to also encourage soil enrichment. An example of an area in Hillwood Estate, Museum and Garden in which the compost tea is applied to is the no-spray rose garden. In this soil, the compost tea serves as an immune booster. Additionally, this rose garden maintains a no-spray status because drought and high soil temperatures are monitored and treated accordingly.

In addition to Hillwood Estate, Museum, and Garden, Chanticleer Garden, George Washington's Mount Vernon, and Oatlands Historic House and Gardens have on-site composting programs, from which compost is taken and reintroduced into the soil as a soil amendment. Notably, Chanticleer Garden uses an O2 composting program. This composting program is an aerobic process, in which electric blowers are used to replenish air to the compost pile, preventing the need to turn over the compost pile during the first 30 days, or the active phase of the composting.[16] This reduces odors and saves time and money. In addition to an electric blower, a timer, a temperature probe, and slide gate valves are used in this composting program.[17] The addition of oxygen increases temperature, which, for this composting program, is maintained at 135 degrees.[18] This high temperature kills weed seeds, parasites, and pathogens, but is low enough to maintain the good microbial activity in the compost pile.[19] Another benefit of this type of composting is that it is not necessary to have a large space, making it feasible for small areas.[20] At Chanticleer Garden, this compost is reintroduced into the garden in beds, soil mixes, and potting mixes and used to restore turf. All green waste from this composting is used and nothing leaves the site. Another way in which Chanticleer Garden manages green waste is by using neighborhood fall leaves as leaf mulch for their garden beds, preventing the need to purchase mulch from outside of the garden. Additionally, George Washington's Mount Vernon has a composting program that incorporates their livestock compost. This livestock compost includes hay, straws, feces, etc., and is mixed with garden compost, which includes grass clippings, leaves, beans, and foliage. All the compost returns to the gardens and fields, preventing landfill waste.

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[12] "Brewing Compost Tea," Fine Gardening, accessed July 26, 2019, https://www.finegardening.com/article/brewing-compost-tea.
[13] "Brewing Compost Tea."
[14] "Brewing Compost Tea."
[15] "Brewing Compost Tea."
[16] "Compost 101," O2 Compost, accessed July 17, 2019, https://www.o2compost.com/the-secret-to-composting.aspx.
[17] "Compost 101."
[18] "Compost 101."
[19] "Compost 101."
[20] "Compost 101."

Healthy soil is an important contributor to pesticide reduction. The compost programs are important because the compost is used as a soil amendment in the garden, creating an environment in which desirable plants can thrive, preventing bare space and subsequently the proliferation of weeds. The United States National Arboretum uses their compost as a soil amendment and mulch for similar purposes, including erosion prevention and nutrient enrichment. They source all their mulch from their property debris. This mulch is a product of grinded logs and trees. Oatlands Historic House and Gardens uses Karbon leaf mulch to cover the garden; this breaks down fast, enriches the soil, is a good weed suppressant, and very lightweight. Chanticleer Garden uses a specific soil amendment, Biochar. Biochar is appropriate for almost all soils, and most useful in nutrient-poor and drought-prone environments.[21] Biochar is a product of a process of burning organic materials with little oxygen.[22] Biochar enhances beneficial soil microbes, water retention, soil acidity control, and soil fertility.[23] It also reduces nitrous oxide emissions, and nitrogen contamination in ground water.[24] Achieving similar benefits regarding reductions in chemical use, Oatlands Historic House and Gardens maintains healthy soil and lawns through the incorporation of TLC as an organic fertilizer. This organic fertilizer maintains grass color, prevents burnt grass, enriches grass health, and reduces herbicide use.

Tudor Place has used goats for invasive species control as an alternative to chemical use. These goats came from the Green Browsing Goats company. The way in which this works is that the goats are limited to an area of invasive species proliferation in the garden. They essentially replace the use of Round Up, a chemical input, by eating the invasive species. However, these goats require a substantial regulation and permit process for the D.C. area. It was noted that if this method for invasive species control is pursued, an efficient number of goats is necessary.

Meadow management, in addition to contributing to fossil fuel emission reductions, also prevents the need for high chemical use. At the United States National Arboretum, meadow management entails soil drenching, which controls fungal practices. Additionally, leaf litter is used as a natural fertilizer in the meadows. Invasive species are a problem in these meadows, but the staff of the United States National Arboretum are investigating burning to control them.

4. Biodiversity and Habitat Conservation

Claudia West of Phyto Studio worked with the United States National Arboretum to create a "green mulch" layer in the Arboretum's Friendship garden. This landscape strategy maintains the cultural "friendship" and environment among pollinators, birds, plants, and humans. In other words, this landscape strategy reinforces biodiversity by encouraging relationships among organisms. This strategy reduces the reliance on traditional mulches and incorporates traditional plantings to create a dense cover ground. This focuses on leaving no bare spaces or isolated plants, which would otherwise create an environment for the proliferation of weeds because of an absence of competitive exclusion. This landscape management approach aims to meet the functional and aesthetic purposes of gardens with the organic properties of the environment to create a natural landscape.

Healthy soil is important for habitat conservation and plant health, and therefore biodiversity. The use of compost as a soil amendment enriches the microbial activity of soil and therefore the ecological relationships between beneficial insects and vegetation. As aforementioned, there is a benefit to using leaf mulch and litter as soil amendments. Additionally, Tregaron Conservancy practices soil conservation, which entails replacing soil throughout construction, reusing soil from the Conservancy to maintain richness. Another benefit of soil conservation includes erosion prevention. Oatlands Historic House and Gardens, through meadow management, maintains healthy soil by keeping it intact. By avoiding disrupting and removing the soil, Oatlands Historic House and Gardens preserves habitats found within the meadows, creating a space for native species to reappear. Also, Oatlands Historic House and Gardens

[21] "Soil Health," International Biochar Initiative, accessed July 17, 2019, https://biochar-international.org/soil-health/.
[22] "Soil Health."
[23] "Soil Health."
[24] "Soil Health."

practices mowing maintenance with consideration to bird nesting. Mowing maintenance defines the frequency and location of mowing. For example, Oatlands Historic House and Gardens avoids mowing in areas of bird habitat during the nesting phase in order to prevent habitat destruction.

Discussion

Some of the gaps in sustainable practices at Dumbarton Oaks are a product of the historic and landscape limitations of the garden itself. For example, cisterns may not be feasible systems to construct at Dumbarton Oaks for stormwater management and water conservation; however, with consideration to the practices already implemented at Dumbarton Oaks, there are practices and ideas involving battery-powered equipment, meadow management, and composting for which improvement at Dumbarton Oaks could be made within the historic limitations.

During the recent water project, the construction of a cistern was a consideration for conserving water. However, due to the location at which a cistern could be potentially constructed and the destruction the construction of a cistern could cause to the landscape, a cistern has not yet been implemented at Dumbarton Oaks. The location for a cistern is a problem because it would be at a lower part of the garden. Usually, cisterns are constructed at higher parts of the garden so that the water supplies downhill. However, an interesting feature of Oatlands Historic House and Garden's cistern is that it is located at a lower part of the garden. The additional problem of the destruction the construction of a cistern could cause is a problem mainly because of its threat to the historical integrity of and habitats within Dumbarton Oaks. Tudor Place, a historic garden, most recently pursued a major cistern project for a large area of their South Lawn (Figure 1). A discovery from this project was that certain cistern systems only allow a certain amount of water to be drawn at a time. In other words, a certain amount of water must always be maintained within the cistern. This does not allow the garden to reap all the benefits a cistern could offer. Despite this, this garden reports that three uses of their irrigation system equal the amount of water the cistern provides. Other considerations regarding the implementation of a cistern include cost and time, which would include time for which the garden is closed to the public for the construction of a cistern.

Figure 1. South Lawn Cistern Project, 2019. Courtesy of Josh Meyer, Tudor Place.

Dumbarton Oaks uses gas-powered equipment. Electric-powered equipment could be a good substitute for this gas-powered equipment. Selecting the appropriate brand would be an important part of this transition. Smithsonian Gardens continues to use battery-powered equipment primarily of the brand DeWalt and Greenworks, while Oatlands Historic House and Gardens continues to use the brand Ryobi, and the staff of both gardens have reported that these brands are reliable. Oatlands Historic House and Gardens, however, admitted that there are better brands than Ryobi but that this brand was appropriate given their budget. As mentioned by a staff member from Green Spring Gardens, the battery life and subsequent amount of batteries needed for certain brands of battery-powered equipment to perform a task poses a problem. Needing multiple batteries creates hardship for the gardeners, as they must carry all these batteries out for each task. Remembering to charge all these batteries is another potential downside; unlike gas-powered, if battery-powered equipment does not have its batteries charged the previous day,

they cannot be used for that given day, thereby preventing certain tasks from being completed. An important consideration could be maintaining gas-powered equipment but relying primarily on electric-powered equipment. The weak horsepower of some brands, which has been reported as a typical downside of some battery-powered equipment, is another important consideration. Further research could entail learning about how the batteries of this battery-powered equipment could be charged. Notably, looking into the use of solar panels to charge this equipment could be an extension of this research. The disposal of batteries could be another extension of this research, given how the carbon-imprint of its construction and disposal could offset the fossil fuel emissions saved from transitioning from gas-powered equipment.

Meadow management is an important feature of both historic and non-historic gardens for weed management, soil compaction control, fossil fuel reduction, and habitat conservation. Meadow management is an important part of the United States National Arboretum, for example; however, as a non-historic garden, the United States National Arboretum does not have the same limitations as Dumbarton Oaks. Given this consideration, other historic gardens have adopted ideas from meadow management. Dumbarton Oaks may not adopt complete meadow management but can also adopt ideas from this practice. Particularly, increasing the standard height for cutting grass and reducing the mowing frequency could be adopted. Dumbarton Oaks has a 3.5-inch standard height for cutting grass and the gardeners generally mow weekly. The United States National Arboretum maintains a standard height between 3 inches and 4 inches. Weed reduction is a product of the maintenance of a higher grass height. Increases to grass height increases shade to weeds, which reduces the weeds' accessibility to sunlight for growth. This means that increasing the standard for grass heights reduces the need for high chemical inputs to manage weeds. Additionally, this has benefits for habitat conservation. Limited mowing can preserve beneficial insects and their built habitats within the grass. The reduction in frequency of mowing reduces fossil fuel emissions and soil compaction from the frequent impact of heavy equipment. Reduction of soil compaction is important for water retention in the soil and to maintain healthy microbial activity, soil habitat for beneficial insects, and plant health. Oatlands Historic House and Gardens notes that native species proliferate in their meadows. The overall idea of adopting practices of meadow management is to reflect the natural environment. This entails minimal interference with habitats. Oatlands Historic House and Gardens adheres to a "quiet garden" principle to follow this idea. Additionally, allowing leaf litter and leaf mulch to be introduced back into the garden or originally maintained is another important consideration for sustainability improvement. The work done at the United States National Arboretum with Claudia West follows a practice of natural landscape management by covering a section of their garden with "green mulch" as opposed to traditional mulches (Figure 2.1, 2.2). The purpose of this is to prevent bare space, which otherwise allows for weed proliferation and destroys habitats for beneficial insects, including pollinators. This is another idea that aims to reflect the natural environment. All in all, a medium between a natural landscape and a garden with a high ornamental threshold could be important for consideration for implementation at Dumbarton Oaks.


Figure 2.1, 2.2. “Green Mulch” layer work with Claudia West, 2019. Courtesy of Christopher Carley, United States National Arboretum.

A robust composting program enhances soil and plant health and reduces chemical use. Hillwood Estate, Museum, and Garden’s holistic plant care, which includes vermicomposting and compost tea (Figure 3.1, 3.2, 3.3), and Chanticleer Garden's O2 composting program are notable considerations. Among some of the benefits of the O2 composting program are time and money saving, and weed, parasite, and pathogen reduction. Vermicast and compost tea together, when introduced back into the soil, increases microbial activity and water retention. Adopting a principle, similar to Chanticleer Garden and George Washington’s Mount Vernon’s, to ensure that no green waste, including the compost, is left from the site is an important sustainable practice. These practices follow the idea to create a natural landscape in that this natural, organic compost is reintroduced back into the environment as leaf mulch or as a soil amendment.



Figure 3.1, 3.2, 3.3. Hillwood Estate, Museum, and Garden’s composting program, 2019. Courtesy of Jessica Bonilla, Hillwood Estate, Museum, and Garden.

Because a major stormwater and water conservation project was recently completed, and an emphasis on an Integrative Pest Management approach to reduce chemical input in the garden is already in place, the topics to focus on regarding sustainability improvement at Dumbarton Oaks should be reducing fossil fuel emissions and increasing habitat conservation and biodiversity. However, the information regarding cisterns gathered from the interviews is appropriate for consideration given the plan to construct a new greenhouse, for which a cistern could source its water. Otherwise, transitioning to

battery-powered equipment appears to be an important trend of gardens, and the combination of meadow management practices and composting programs is most relevant to addressing habitat conservation and biodiversity—and these practices simultaneously address chemical input reduction and water conservation. The staff of Dumbarton Oaks are currently looking into and staring a compost tea program and therefore are already focusing on this practice. Overall, I learned that most of the practices that define sustainability adopt features that encourage or reflect a natural landscape. This report functions as a reference for relevant points of contact for information regarding important practices of these four topics of sustainability, a starting point for further research, and as a reference for considerations and recommendations for practices to focus on to improve sustainability at Dumbarton Oaks Garden.

Acknowledgements

Staff of Washington, D.C. area gardens who contributed to this report:
Michael Mastrota and Stephanie Destefano, American University Arboretum and Gardens
Erin McKeon and Jeff Lynch, Chanticleer Garden
Nicole Conners, Green Spring Gardens
Jessica Bonilla, Mathew Boyle, Hillwood Estate, Museum, and Garden
Dean Norton, George Washington's Mount Vernon
Mark Schroeter, Oatlands Historic House and Gardens
Lynn Parseghian and Tamara Belt, Tregaron Conservancy
Josh Meyer, Tudor Place
Cynthia Brown, Vickie Dibella, Jeffrey Schneider, Sarah Hedean, Matt Millage, Alex Dencker and Holly Walker, Smithsonian Gardens
Scott Aker, Christopher Carley, Anthony Vlahakis, Carole Bordelon and Kevin Tunison, United States National Arboretum

Gardeners and staff of Dumbarton Oaks who contributed to this report:
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[i] **Dumbarton Oaks Water Use Records**

Period	Gallons
6/3/2019 - 2/14/2018	33,876.0972
4/27/2018 - 5/30/2017	36,901.9816
5/30/2017 - 6/29/2016	42,718.28
6/29/2016 - 6/29/2015	40,272.32
6/29/2015 - 6/26/2014	49,816.8
6/26/2014 - 6/26/2013	52,000.96

[ii] **Dumbarton Oaks Equipment Inventory**

Equipment	Description (number of)
Aerator	Bluebird Aerator 530 (1)
Blowers	Stihl Magnum Blower (5) Echo Blower (2) Little Wonder Blower (1)
Chainsaws	Stihl Chainsaw (3)
Generator	Generator (1)
Leaf Vacuum	Leaf Vacuum (1)
Mosquito Fogger	Mosquito Fogger (1)
Mowers	Toro 30" Mower (3) Briggs and Stratton Mower (1) Exmark 21" Commercial Mower (1) Kubota 21" Commercial Mower (1) Scag 36" Commerical Mower (1) Exmark 36" Mower (1)
Seeder	Bluebird Seeder (1)
Snowblowers	Toro Snowblowers (2)
Sprayer	50 gal Sprayer (1)
Tillers	Honda Tiller (1) Troy-Bilt Tiller (1)
Trimmers	Stihl Trimmer (2)
Tractor	Kubota Tractor (1)
Vehicles	2000 Chevy (1) 2010 Ford (1) 1994 Chevy (1)
Weeders	Echo Weedeater (1) Stihl Weedeater (3)

[iii] **Dumbarton Oaks Pesticide Inventory**

Pesticides (target of treatment)

- Safari, Enstar (mealybug)
- Quali-Pro propiconazole, Eagle 20 EW (leaf spots)
- Baseline (bark beetles)
- Dow Confront (broad leaf weeds)
- Ultra-fine horticultural oil (white fly)
- Quali-Pro Strobe (needle cast)
- Round up (weeds)
- Adorn and Subdue (root rot)

Application Equipment

- Big sprayer
- Agrotech
- Backpack

[iv] **Local Gardens Battery-Powered Equipment Inventory**

Garden	Type of Equipment	Brands of Battery-Powered Equipment (Make, Model)
Hillwood Estate, Museum and Garden	Blower Electric Sprayer	Greenworks (Little Wonder, 9901) Rocket Spray (XL Pro)
Oatlands Historic House and Garden	Electric Weed Eater Blower Cordless Electric Hedge Trimmer Lawnmower	Ryobi Ryobi Black and Decker SunJoe 40-volt
Smithsonian Gardens	Handheld Leaf Blower Weed Whacker Chainsaw Leaf Blower Gator TE Hybrid Diesel/Electric Stake Body Trucks	DeWalt (DCBL790H1) DeWalt (DCST990H1) DeWalt (DCCS690M1) DeWalt (DCBL590X2) John Deere (2009, 2010, 2011, 2016) Frieghtliner (M2-106, 2012)