October 2017

GWYNNS FALLS / LEAKIN PARK

Forest Management Plan

CITY OF BALTIMORE

BALTIMORE CITY
RECREATION & PARKS

TreeBaltimore

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Acknowledgements

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Baltimore Ecosystem Study

Friends of Gwynns Falls Leakin Park

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EXECUTIVE SUMMARY

The City of Baltimore has identified a need to develop a Forest Management Plan for the approximately 1,200 total acres of Gwynns Falls/ Leakin Park (GFLP) located along the western edge of the city. The purpose of this plan is to guide the City in managing the variety of forest communities within the park and to achieve successful reforestation, new forest establishment in some areas, and comprehensive improved forest condition.

Furthermore, this plan is intended to provide the City with: 1) assessment and prioritization for control of invasive plant species concentrations within the park, 2) recommendations for management activities required to improve overall forest health, and 3) the budget projections required to conduct effective management activities that occur within the plan.

The project efforts included a characterization of existing vegetation communities and evaluation of site conditions, a site prioritization and both short- and long-term maintenance recommendations, as well as planning-level cost estimates for management implementation.

Predictable patterns of non-native plant invasion are evident in forest edge areas. Vectoring sources in these areas include roadway edges, rail lines, rights-of-way, paths, and other disturbance areas such as former dump sites. The large suite of invasive species present threatens the existing afforestation site planting success, poses future threats to less invaded newer afforestation sites, and compromises tree health and native species regeneration within areas of more mature forests. Deer abundance and the need for deer management is also a key factor. There are a wide range of conditions and priorities for intervention across the park based on multiple metrics, ranging from ecological to cultural factors. The top priority sites include the better condition forests near the neighborhoods of Rognell Heights, Dickeyville, Hunting Ridge, West Hills and Wakefield. It is desirable to protect and enhance the less impacted areas first and progress into more impacted sites over time.

Management activities and estimated costs for the initial management and continued maintenance vary from stand to stand and over time. Annual costs are anticipated to decrease with each subsequent maintenance year until monitoring and “spot” treatment efforts are required. It is also anticipated that treatment and management would occur by stand, and staggered over time as funding allows.

1 INTRODUCTION

1.1 Background- Purpose and Need

Baltimore City's Department of Recreation and Parks, Urban Forestry Division, is charged with the health and care of the urban tree canopy found on Baltimore's public spaces. Through the Division's Tree Baltimore Program, the city identifies steps needed to increase both the quantity and quality of its tree canopy cover – including the woodlands within park property. Through this Program the city can develop a specific blueprint to improve the canopy found within Gwynns Falls – Leakin Park's (GFLP's) approximate 1200 acres in west Baltimore (see Figure A: Vicinity Map).

This Forest Management Plan (FMP) assesses GFLP's forest health and provides specific recommendations for improvement. Additionally, the Plan assesses long-term sustainability of the forest, to support abundant species/age diversity and ecological services, as well as the forest's resilience to human disturbances and natural phenomena.

1.2 Goals and Objectives

The GFLP FMP should be considered a "living," working document that is implemented and advanced over time. The work programs recommended in it should be reviewed annually and adjustments made appropriately for the following year. The entire document itself should be reviewed on a five to ten-year basis to determine if management and forest conditions have changed significantly and to determine if an update or amendment is needed. During these reviews, the following components should be considered:

- Observations and occurrences of new or worsening threats and stressors.
- Operational review with recommendations for improved work procedures, equipment inventory, budget level, and administrative efficiencies.
- Ordinance, policy, and procedure review and recommended revisions.

This management plan establishes a clear set of priorities related to achieving the goals and objectives of improving and increasing the urban tree canopy, creating a healthy and sustainable urban forest, improving wildlife habitat, and protecting water quality. The priority strategies focused on in this management plan include:

- Afforestation of available non-forest areas.
- Reforestation of forest areas with limited regeneration.
- Treatment and removal of non-native invasive vegetation.
- Protection of artificial and natural regeneration from deer damage.
- Improvement of soil conditions through surface application of mulch.
- Removal of refuse and trash from forest.

Gwynns Falls
Forest Management Plan
Baltimore, MD

Figure A: Vicinity Map

Legend

GFLP Park Boundary

Service Layer Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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2 ASSESSMENT METHODS

2.1 Data Collection

Existing Information Review

As context for the project, the FMP team reviewed the following background documents for GFLP:

- Gwynns Falls Watershed Natural Resource Management Plan (1994)- Recommendations for cultural and natural resource improvement by the Urban Resources Initiative (URI), in cooperation with the Parks & People Foundation, and the Baltimore City Department of Recreation and Parks.
- Hack the Parks Invasive Vine Mapping: Gwynns Falls Leakin Park (2013)- Qualitative mapping on vine presence by The Friends of Gwynns Falls Leakin Park.
- Crimea Area Master Plan (2006)- A cultural resources-focused plan by Heritage Landscapes for the historic Crimea Mansion landscape and surrounding forest.
- GIS Data- geospatial data files provided by Baltimore Recreation and Parks including: 2007 tree canopy, streams, buildings, roads, trails, and topography.

Stand Mapping

This assessment defines a forest "stand" as a contiguous area of forest with similar site characteristics and trees of a similar successional state, species composition, size class distribution, and overall structure. Organizing the forest into stands facilitates data collection and allows management recommendations to more accurately represent and apply to areas with similar environmental conditions and vegetation.

Stands can often be defined in the context of their particular disturbance history. Thus, the project team reviewed historic aerial photographs from 1927, 1953, and 1972 (Johns Hopkins Sheridan Libraries), as well a current aerial photograph from 2015 (NAIP) and existing conditions (see Figure B: Existing Conditions) for changes in land use and tree canopy coverage over time. More enduring site characteristics such as geology, soils, topography, and hydrology were also reviewed to identify areas of similar characteristics. This review, and adjustments from subsequent field work, identified 34 forest stands. As GFLP is an extensive site with many stands, the stands were later grouped into six Management Units (see Figure C:

Stands & Management Units). The Management Units are based on geographic proximity and common accessibility for management activities. They are also intended to assist with general wayfinding to the various stands.

NED-3 Field Data Collection

Data collection and data analysis phases utilized NED-3, Beta version 3.0.6.31 (Twery and Thomasma 2017), a software product by the USDA Forest Service. NED-3 was developed to help resource managers assess current and future forest conditions, and produce sustainable management plans. Following the NED-3 protocol for forest data collection, forest data is collected in numbered plot clusters. For this analysis, a plot cluster consists of:

- one 0.1 acre, fixed area, circular overstory plot (≥10' height trees)
- two 0.01 acre, fixed area, circular understory plots (vegetation from 0' to <10' height)
- one 207' long transect for coarse woody debris (CWD) sampling

Forest sampling followed a systematic approach, stratified within stands. To establish plot sampling center points, the 207' by 207' point grid from the Friends of Gwynns Falls/ Leakin Park Invasive Vine Mapping (2013) was employed. The intent is that this grid can be utilized in other studies moving forward, for some level of spatial consistency, and potential comparison. A coarser grid of 414' by 414', intersecting points of the 2013 Vine Mapping, was established for this FMP's "A-Plot" center point locations for field data collection. From the resulting grid, 186 A-Plot center points were selected for maximum coverage across the forest stands and topography gradients, as the basis for 186 plot clusters (see Appendix B, Figure B-1: Sample Plot Locations). A-Plot points were the center for one overstory plot and one understory plot in each plot cluster. In some instances, A-Plot points were shifted onto the finer 207' by 207' grid if the A-Plot point would otherwise fall on lawn, in a body of water, or outside the study area. The second understory plot, or "B-Plot" for each cluster, was selected from the 207' by 207' 2013 Invasive Vine Mapping grid. Each B-Plot was one grid point away from an A-Plot. B-Plots were selected to stay within stand boundaries and to capture topography gradients. The 207' long CWD sampling transect for each cluster connected each A-Plot and B-Plot.

Plot observations were conducted in September and October 2016. Warmer weather continued into late October, and with the exception of some senescing species, many plants could be identified by leaves. Spring ephemerals and any other plants that did not have visible above ground biomass were not observable and therefore not recorded.

Gwynns Falls
Forest Management Plan

Baltimore, MD

Figure B: Existing Conditions

Gwynns Falls
Gwynns Falls
Windsor Mill Rd
N Franklintown Rd
Gwynns Falls
Hilton Pkwy
Dead Run

Legend

- 10 ft. Contours
- Multi-use Trails
- Hiking Trails
- Buildings
- Streets
- Streams
- Waterbodies
- Forest
- Lawn/ Grasses

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Gwynns Falls
Forest Management Plan

Baltimore, MD

Figure C: Stands & Management Units

Legend

- Streams
- GFLP NE — Management Units
- A — Forest Stands
- Buildings
- Property
- Streets
- Waterbodies
- Forest
- Lawn/ Grasses

0 500 1,000 1,500 Feet

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At each overstory plot, canopy closure (>30' height) and midstory closure (10' to 30' height) was visually estimated. Midstory type (coniferous, deciduous, or mixed) was recorded, as well as whether the plot was located in a riparian area. 3,756 overstory trees were observed and measured in the 186 overstory plots. For each overstory tree, the following was recorded: species (except for standing dead trees), DBH at 4.5' above ground as measured with tree diameter tape, tree living or dead, cavity in tree, crown class (open grown, dominant, codominant, intermediate, suppressed), presence or absence of vines on the tree. Crown condition of live trees was also recorded as good (>75% live branches), fair (50 to 75% live branches), or poor (<50% live branches).

Understory plot observations were collected within two different height classes: shrub stratum (3' to <10' height) and groundcover stratum (0' to <3'). In the shrub stratum, the following was recorded: estimated average height of shrubs, species, DBH, and count (for trees), species and percent of plot coverage (for shrubs and herbaceous plants). In the groundcover stratum, the team recorded: average height of plants in the stratum, seedling species and count (for trees), and percent coverage (for shrubs and herbaceous plants). The team also recorded the following percentage cover for each understory plot: moss, tree litter, rock cover, regeneration inhibited ferns, other ferns, grasses and sedges. Litter depth was also measured as well as the presence or absence of: wet soil inhibited regeneration, rockiness inhibiting regeneration, riparian area, wetland vegetation, edge conditions, trash, seeps, streams, vernal pools, loose soil, rock piles, and rock crevices below the frost line.

CWD data collection followed the line transect method (Twery et al. 2011, Howard and Ward 1972). On each 207' long transect between A- and B-Plots, all downed wood was recorded that was greater than or equal to 3" and a length of at least 3'. The diameter of each qualifying CWD piece was measured at the transect and recorded, as well as whether the wood piece was hard or soft from decay, and presence/absence of bark.

Data Input into NED-3

All data was recorded in the field by hand on modified NED-3 hard-copy data sheets. Data was then transcribed and manually entered into the NED-3 computer program. All data were standard entries in NED-3, except for three custom variables: vines in trees, presence/absence of trash, presence/absence of an edge condition. Forested acres for each stand were calculated

in ArcMap from the 2007 tree canopy GIS file provided by Baltimore City Department of Recreation and Parks and entered into NED-3. Twenty randomly chosen plots clusters (just over 10% of the 186 total plot clusters) were reviewed for Quality Assurance/Quality Control (QA/QC) by an internal third-party for accuracy of data entry. Any errors were corrected and the rest of the plot clusters were also reviewed for those same types of errors and corrected.

2.2 Data Analysis

Data supporting the goals of the FMP and potential management recommendations were organized, calculated, and summarized. Standard NED-3 reports were run at the forest summary and stand level for Overstory Vegetation, Understory Vegetation, Biomass, Ecology, Timber, and Wildlife. Numerous custom tables at the forest summary and stand level were also run. NED-3 does not readily summarize all combinations of variables that are of interest to this assessment. Therefore, Excel and ESRI ArcMap were utilized for additional calculations for invasive species and other species or genus-specific queries.

3 EXISTING CONDITIONS

3.1 Regional Vegetation Context

Historically, the site characteristics of GFLP would support a predominantly American chestnut (*Castanea dentata*) and/or mixed oak-hickory forest (*Quercus* spp. and *Carya* spp.) typical of the Mid-Atlantic region. However, several changes in disturbance patterns over the last century have reduced the regenerative capacity of most oak trees. This condition can be seen in the forests of GFLP.

The initial dramatic change to regional forests occurred near the turn of the 20th century with the introduction of *Cryphonectria parasitica*, a fungal disease, which reduced the American chestnut from a dominant tree species in the eastern forest to barely an early-succession-stage shrub. The chestnut blight removed an important wildlife food source as well as a key component to a dominant ecological community. In addition, the disturbance-controlled oak-hickory forests of GFLP were kept in place through a history of periodic surface fires coupled with occasional canopy-level disturbances such as intense storms, including tropical storm systems, ice storms, and tornadoes. As fire has been controlled for more than the last century it no longer minimizes the occurrence of thin-barked, shade-tolerant hardwood species such as American beech (*Fagus grandifolia*), red maple (*Acer rubrum*), and sugar maple (*A. saccharum*) in the understories of oak forests. In the absence of fire, these species form dense midstory canopies that reduce understory light to the point that oak regeneration dies or cannot develop roots to reach a competitive size. Therefore, when a canopy gap occurs, it is filled by American beech or maple instead of an oak. Fire also limits the occurrence of fast-growing, shade-intolerant native hardwood species such as black cherry (*Prunus serotina*) and tulip poplar (*Liriodendron tulipifera*) that can invade and capture canopy gaps. These canopy gaps are also being filled by the multiple non-native invasive (NNI) species that have proliferated during the last century. These aggressive, fast growing plants easily out-compete native seedlings, including oaks.

Another change that has occurred to the oak forests that has had negative consequences is the proliferation of white-tailed deer (*Odocoileus virginianus*), which not only consume acorns, but also preferentially browse oak seedlings while avoiding less palatable species such as black cherry, American beech, and red maple (Cote et al. 2004, Lister and Widmann 2016). In more

recent decades, exotic pests, such as gypsy moth (*Lymantria dispar*), that preferentially defoliate oaks, have spread throughout the region. Periodic outbreaks of this pest kill additional oak trees, reducing the frequency and size of acorn crops, and the potential for oak regeneration. This new disturbance regime (no fire, chronic deer browsing, more frequent canopy disturbances that target oaks) has reduced the number of oaks in the forest, and has also hindered regeneration. Consequently, where oak species once were a prominent or dominant forest species, the species mix is changing in the region and in GFLP, favoring other tree species.

A reduction in oak species in the forest canopy has a significant impact in the function of forest ecosystems. In the Mid-Atlantic, oaks support over 500 species of butterflies and moths, more than any other plant genus (Tallamy and Shropshire 2009). Those butterfly and moth species are in turn an important part of the diet of insectivorous birds, such as warblers and vireos, and small mammals. Additionally, oak acorns are a key food source for song birds and mammals, such as squirrels, chipmunks, and rabbits. In total, 49 species of birds and mammals in the eastern US use oak nuts and foliage (Sprague et al. 2006). There is also evidence that oak dominated forests release less nitrogen to streams compared to beech and maple dominated forests (Lovett et al. 2004). While other native tree species provide habitat value and regulate certain ecosystem functions, oaks have a particular ecological importance in the Mid-Atlantic region and the Chesapeake Bay watershed.

3.2 Park Site Context

GFLP is in the western part of Baltimore, Maryland and at approximately 1200 total acres, is the largest park in Baltimore and one of the largest single urban parks in the United States. Of that approximate 1200 total acres, about 800 acres are forested. GFLP is bordered by the Baltimore City neighborhoods of Purnell, Dickeyville, Wakefield, Franklintown, West Hills, Hunting Ridge, Rognell Heights, Edmondson Village, Rosemont, Fairmont, Mount Holly, Windsor Hills and West Forest Park. The park is situated completely within the Gwynns Falls subwatershed of the Chesapeake Bay watershed.

GFLP is located in the eastern division of the Piedmont physiographic province, which is characterized by the Atlantic Seaboard fall line along its eastern boundary. The GFLP forest and underlying topography organizes around the Y-shaped confluence of Gwynns Falls and Dead

Table A: Stand Summary

Management Unit	Stand	Forested Area (ac)	Percent Area >15% Slope	Basal Area/ Acre	Overstory Trees/ Acre	Forest Type	Dominant Tree Species in Canopy	Dominant Tree Species in Understory (based on basal area)	Dominant Tree Species in Understory (based on stem counts)
Dickeyville-Purnell	Stand A	23.0	34%	109	260	Mixed Floodplain Hardwoods	white oak, American elm and boxelder	American elm and boxelder	green ash
Gwynns Falls Floodplain	Stand B	40.3	34%	76	199	Mixed Floodplain Hardwoods	tulip poplar, American sycamore and eastern cottonwood	American elm and green ash	green ash
Gwynns Falls Floodplain	Stand C	24.6	25%	110	248	Mixed Floodplain Hardwoods	green ash, boxelder	green ash, boxelder, and American elm	green ash
Dead Run Floodplain	Stand D	44.4	29%	131	302	Mixed Floodplain Hardwoods	American sycamore, tulip poplar and green ash	American elm, green ash, American beech	green ash
Dickeyville-Purnell	Stand E	11.1	85%	148	200	Tulip Poplar-Oak	tulip poplar and American beech	American beech and red maple	pignut hickory and American beech
GFLP NE	Stand F	12.8	65%	167	290	Tulip Poplar-Beech	tulip poplar	American beech, red maple, and tulip poplar	green ash and boxelder
GFLP NE	Stand G	25.8	84%	292	295	Tulip Poplar-Oak	tulip poplar and white ash	American beech and white ash	white ash
GFLP NE	Stand H	25.1	61%	196	138	Tulip Poplar	tulip poplar	boxelder	white ash
GFLP NE	Stand I	14.7	87%	195	232	Oak Northern Hardwoods	white oak and American beech	white ash, Norway maple, American beech	white ash
GFLP NE	Stand J	25.2	29%	158	430	Mixed Hardwoods	white ash, northern red oak and white oak	white ash, boxelder, and black cherry	white ash
GFLP NE	Stand K	20.1	54%	126	278	Mixed Hardwoods	American beech, red maple and tulip poplar	American beech	white ash
GFLP NE	Stand L	6.4	66%	54	130	Mixed Hardwoods	white ash and boxelder	boxelder and white ash	white ash
GFLP NW	Stand M	25.5	36%	170	198	Tulip Poplar	tulip poplar	American beech	white ash and bitternut hickory
GFLP NW	Stand N	15.5	64%	171	255	Tulip Poplar-Beech	tulip poplar and American beech	American beech	white ash and American beech
GFLP NW	Stand O	17.8	47%	97	152	Mixed Hardwoods	tulip poplar, tree of heaven and Norway maple	boxelder	white ash
GFLP NW	Stand P	26.0	9%	136	310	Tulip Poplar-Oak	tulip poplar, white oak and white ash	tree of heaven, white ash, and American beech	green ash and white ash
GFLP NW	Stand Q	19.6	14%	151	192	Mixed Hardwoods	tulip poplar, white ash and black walnut	white ash	white ash and hickory
GFLP NW	Stand R	45.2	41%	158	164	Tulip Poplar Bottomland Hardwoods	tulip poplar and green ash	red maple	green ash
GFLP NW	Stand S	46.9	67%	157	289	Tulip Poplar-Beech	tulip poplar and American beech	American beech, American elm, and tulip poplar	white ash
GFLP NW	Stand T	27.7	50%	202	382	Tulip Poplar-Oak	tulip poplar and white oak	American beech and flowering dogwood	American beech and white ash
GFLP NW	Stand U	13.6	59%	200	248	Mixed Hardwoods	American elm and tulip poplar	American elm	white ash
GFLP NW	Stand V	20.5	68%	187	303	Tulip Poplar-Oak	tulip poplar, American beech and white ash	American beech	white ash
GFLP NW	Stand W	17.3	66%	107	170	Mixed Hardwoods	white oak and tulip poplar	American beech	tulip poplar, green ash and white ash
GFLP SW	Stand X	17.63	43%	168	434	Tulip Poplar-Beech	tulip poplar, American beech and white oak	American beech	green ash and American beech
GFLP SW	Stand Y	23.7	59%	213	573	Oak Northern Hardwoods	black oak, white oak and tulip poplar	American beech	white ash, American beech and white oak

Table A: Stand Summary (cont.)

Management Unit	Stand	Forested Area (ac)	Percent Area >15% Slope	Basal Area/ Acre	Overstory Trees/ Acre	Forest Type	Dominant Tree Species in Canopy	Dominant Tree Species in Understory (based on basal area)	Dominant Tree Species in Understory (based on stem counts)
GFLP SW	Stand Z	19.1	59%	179	430	Tulip Poplar-Beech	tulip poplar, American beech and white oak	American beech	white ash, American beech and green ash
GFLP SE	Stand AA	5.4	89%	192	380	Tulip Poplar-Oak	black oak, tulip poplar and oak	American beech	American beech
GFLP SE	Stand BB	20.9	86%	153	332	Oak Northern Hardwoods	black oak, American beech and tulip poplar	American beech	American beech and red maple
GFLP SE	Stand CC	21.2	87%	139	440	Tulip Poplar-Oak	black oak and chestnut oak	American beech and red maple	American beech and red maple
GFLP SE	Stand DD	22.1	39%	206	242	Tulip Poplar-Oak	tulip poplar	American elm and hickory	green ash, American elm and pignut hickory
GFLP SE	Stand EE	16.3	60%	102	300	Mixed Hardwoods	American beech and green ash	American beech	American beech and green ash
GFLP SE	Stand FF	54.6	75%	139	270	Tulip Poplar-Oak	tulip poplar, white oak and green ash	American beech, American hornbeam, and eastern redbud	green ash, white ash and American beech
GFLP SE	Stand GG	46.9	46%	134	167	Mixed Hardwoods	tulip poplar and green ash	American elm and boxelder	green ash, hickory and tree of heaven
GFLP SE	Stand HH	22.4	65%	132	315	Mixed Hardwoods	green ash and white oak	hickory, Norway maple, and ash	hickory and white ash
			Stand Area-Weighted Average	**147**	**290**				

Run (see Figure B: Existing Conditions). These water courses run through a floodplain ranging from approximately 100' to 700' wide. Steep slopes and rocky valley walls rise from the edge of the floodplain, a regional fall line zone characteristic (see Appendix B, Figure B-2: Slopes). Gradients generally level out in plateaus near the park boundaries. Elevation along these slopes, from park perimeter to floodplain, changes by as much as 250', with the highest elevation at 403' above sea level. Through folds in the slopes, un-named perennial and ephemeral streams drain on a steep gradient north and south to Gwynns Falls and Dead Run. These changes in elevation create significant heterogeneity in site characteristics for vegetation growth.

3.3 Forest Stand Results

Forest Types and Overstory

The 34 stands of GFLP range in size from 5.4 to 54.6 forested acres (See Table A: Stand Summary). Primarily based on overstory tree species and their relative dominance, these stands are categorized into seven NED-based forest types (see Figure D: Forest Types). The Tulip-Poplar Oak forest type (214.5 acres) covers the most area of GFLP. Tulip Poplar Bottomland Hardwoods covers the least area at 45.2 acres (see Table B: Acres of Forest Types). Tree species in the forest are almost exclusively deciduous, except for a minor presence of Virginia pine in Stand FF.

Table B: Acres of Forest Types

Forest Type	Forested Stand Area (ac.)
Tulip Poplar-Oak	214.5
Mixed Hardwoods	205.6
Mixed Floodplain Hardwoods	132.2
Tulip Poplar-Beech	112.0
Oak Northern Hardwoods	59.2
Tulip Poplar	50.6
Tulip Poplar Bottomland Hardwoods	45.2
Total	819.2

Tulip poplar dominates the forest canopy with a forest-wide basal area of 58 square feet/acre or 37% of the forest basal area. It is also the third most common overstory tree species on a tree per acre basis, with almost 1 in 10 trees at 10' height or greater being tulip poplar. Tulip poplar is a wind dispersed, fast growing, shade intolerant, pioneer species. It was likely among the first

canopy tree species to occupy many of the GFLP forest stands, and its fast growth allowed the species to race to the top and dominate the canopy.

Six species of oak are present at GFLP, and collectively they are the second most dominant tree group in the overstory at 20% of the forest basal area. Six percent of trees at 10' height or more are oaks, making oaks the fifth most common genus in the overstory on a tree per acre basis. Oaks have the greatest overstory basal area presence in Stands Y, AA, CC, and I, all with greater than 90 square feet/ acre basal area. Four stands (Stands F, L, O, and R) have no oak presence in the canopy. Oak acorns are dispersed by falling, rolling, or being transported by animals such as squirrels. They are slower growing than tulip poplar and shade intolerant to mid-tolerant, depending on the specific species.

As measured by basal area, which has some correlation to canopy size, the next set of canopy dominant trees includes, white and green ash together (*Fraxinus americana* and *F. pennsylvanica*), American beech, and American elm (*Ulmus americana*), each with 5% or more of the total forest basal area. As measured by abundance of stems, American beech ranks highest at almost 1 in 4 trees at 10' height or greater. On a tree per acre basis, American beech is followed in abundance by the ash genus, American elm, tulip poplar, the oak genus, boxelder (*Acer negundo*) and red maple, each having over 10 trees/acre. Thus, the current canopy favors tulip poplar and oak species, while the slower-growing, but shade tolerant American beech dominates in sheer numbers in the midstory. Absent management activities or significant disturbance, tulip poplar and oak in the canopy will die over time and be replaced by American beech.

Stand Successional State

In 2006, Groffman et al. estimated that mature trees in Baltimore Ecosystem Study plots in Gwynn Falls Park were 80 to 100 years old. This would put today's forest in the range of 90 to 110 years old. A brief analysis of historic aerial photography for this report generally conforms with Groffman et al.'s (2006) approximation, but suggests that some stands may be closer to 60 to 70 years old. In 1927 aerial photography (Johns Hopkins Sheridan Libraries), only 15 of 34 stands (as delineated for this study) appeared to have mostly midstory or overstory vegetation coverage (Stands D, G, H, I, N, T, U, X, Y, Z, AA, BB, CC, EE, GG). All other stands had significant gaps in tree cover, or were mostly open fields or lawn. By 1972, aerial photography

Gwynns Falls

Forest Management Plan

Baltimore, MD

Figure D: Forest Types

Legend

10 ft. Contours

A — Forest Stands

Forest Type

- Mixed Floodplain Hardwoods
- Tulip Poplar Bottomland Hardwoods
- Mixed Hardwoods
- Tulip Poplar
- Tulip Poplar-Beech
- Tulip Poplar-Oak
- Oak Northern Hardwoods

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(Johns Hopkins Sheridan Libraries) shows that 31 stands had significant tree cover and 13 stands (Stands A, B, J, K, L, O, P, Q, S, W, FF) had large interior gaps.

While tree ring increment cores have not been taken for trees in GFLP to accurately sample tree ages, Stands I, N, Z, AA, CC, EE, and GG appear to be in the latest successional state (i.e., 'older growth forest'), relative to the rest of forest. This assumption is based on observations of 1927 aerial photos, a basal area distribution concentrated in larger diameter classes, presence of late-seral dominant species in the canopy (such as oaks and American beech), and presence of larger diameter snags. Of those six stands, Stands CC, EE and GG have the highest rate of snags as a percentage of total standing trees distributed throughout diameter classes (see Appendix A, Table A-3: Snags and Coarse Woody Debris). That is a characteristic of relatively later successional states. Also of the six late seral stands, Stands Z, AA, and CC have the lowest concentration of NNI species, and a dominant presence of oak and American beech in the canopy. These two factors are not necessarily indicative of stand successional state, but in combination with the assumed age of the stands, they do indicate a measure of rarity for GFLP.

Today, all stands are dominated by trees ≥16" DBH, except Stand L at 11.5" medial DBH and Stand CC at 14.1" medial DBH (see Appendix A, Table A-1: Canopy Closure and Density). Medial diameter represents the size class-weighted midpoint of the tree basal area distribution. In combination with historic aerial photo review, this indicates that while some stands may have a few decades in age difference, the vast majority of forest stands at GFLP are of similar age and are at a similar stage of succession. The interior gaps within stands generally lack a robust presence of tree seedlings or saplings. Thus, the forest lacks stand-level successional diversity, and does not provide large habitat areas for early successional (grassland and shrubland) animal species such as ground nesting birds.

Canopy Closure

Overstory canopy closure of forested areas ranges widely from 20% in Stand L to 88% in Stands G, Z and AA, averaging 68% across the site (see Appendix A, Table A-1: Canopy Closure and Density). The majority of canopy conditions will therefore moderately to highly favor shade tolerant species below the canopy level. Midstory closure (10' ht. to 30' ht.) also varies significantly from 14% in Stand M to 83% in Stand HH, with an average across the forest of 42%. Generally, forest stands at GFLP have either a high overstory or high midstory canopy closure, creating a high level of shade below those strata. This combination generally favors

tree species with some level of shade tolerance, such as American beech and maples, in the understory and groundstory.

Relative Density

Relative density is a measure of the degree that growing space is occupied by trees in a forest stand, with a high relative density indicating that a high amount of growing space is already occupied. The measurement takes into account basal area, trees/acre, species, and stand stratification (Brose et al. 2008). While mixed species, uneven-aged stands, like those at GFLP, can affect the accuracy of this metric, when relative density is combined with other observations it can be a useful reference to understand the status and trajectory of forest stands. The area-weighted average of all stands comes to 92% relative density. Twelve stands (Stands G, I, J, T, U, X, Y, Z, AA, BB, CC, and HH) have over 99% relative density of over- and understory trees (see Appendix A, Table A-1: Canopy Closure and Density). These stands will generally have higher competition and growing stress in canopy trees, slow growth in intermediate and suppressed crown classes, and sparse tree seedling and sapling presence of species that are shade intolerant (Nyland 2016). Canopy tree mortality will also likely be higher until mortality and disturbances release additional growing space in coming decades (Smith et al. 1997). Stand G with a 121% relative density and very high basal area of canopy trees in a codominant crown class, and Stand U with a 134% relative density and very high basal area in the suppressed crown class may have the most pronounced of these conditions, as they have very high stress and competition below the canopy dominant trees.

Two stands (Stands B and L) have a relative density less than 60, indicating that trees have not occupied the stands' growing space to the point of significant competition. Tree biomass also has a strong correlation with relative density, with the lowest relative density stand (Stand L) also having the lowest estimated biomass, and the highest relative density stand (Stand Y) having the highest estimate of biomass (see Appendix A, Table A-1: Canopy Closure and Density). Thus, while growth may be slow and tree stress may be higher in the high relative density stands, total above and below ground biomass and carbon pools will be higher. Higher carbon pools can contribute more to the ecosystem service of carbon sequestration.

Saplings and Seedlings

In the sapling category of trees from 3’ to <10’ in height, American beech dominates the understory of GFLP with almost 50 trees/acre and a presence in 25 of 34 stands. American witch-hazel (*Hamamelis virginiana*), a large shrub/ small tree follows next in abundance, then green and white ash, and American elm, all with over 5 trees/acre. Ash, a wind dispersed genus, has by far the greatest presence as seedlings in the 0’ to <3’ stratum, with an average of 624 seedlings/acre. The abundance is also wide-spread, making up over 50% of the seedlings in 26 of 34 stands, with three stands (Stands H, L, and P) containing 100% ash seedlings. American beech at 64 seedlings/acre, hickory genus, oak genus, and red maple follow next in abundance.

As the dominant tree genus by basal area and net volume in Maryland (Lister et al. 2011, Lister and Widmann 2016), oaks are an instructive reference for considering seedling numbers. References for quantities of seedlings/acre needed to replace a stand of oak range from 3,600 (Sprague et al. 2006), to 9,600 in low deer impact conditions, to 77,000 in very high deer impact conditions (Brose et al. 2008). The reference seedling rates noted above are for having enough seedlings to regenerate an oak stand for an overstory harvest. However, the seedling rates still have relevant parallels to natural storm disturbances that topple trees and pest or disease infestation that kills part of the canopy. Additionally, National Park Service forest vegetation monitoring for the Mid-Atlantic (Comiskey & Wheeler 2015) rates forests with less than 8,000 seedlings/acre, of any species mix, to be of significant concern in high deer density conditions.

The highest seedling count in any stand of all species combined is 3,850/acre in stand J. Twenty-four stands have less than 1,000 seedlings/acre, and Stand M ranks lowest with only 42 seedlings/acre (see Appendix A, Table A-2: Understory and Ash Summary). This low rate of seedling presence raises concerns for long-term forest health at GFLP. A well-stocked seedling and sapling layer is necessary to become future canopy when the current tulip poplar and oak dominated canopy declines. The existing successional state of the GFLP forest has some bearing on these numbers, as the average relative density and canopy closure are high, which increases competition for seedlings and saplings that are not shade tolerant. However, this and other conditions discussed below indicate major pressure on tree regeneration from deer browsing and invasive plant species competition.

Understory Shrubs and Herbaceous Species

Spicebush (*Lindera benzoin*) dominates both the 3' to <10' stratum, and the 0 to <3' stratum in the understory, comprising a total of 35% of the understory that is covered by plant material and a presence in the understory of all forest stands at GFLP. Spicebush is typically an indicator species of moist to wet sites. On mesic and dry sites, its presence is often reduced or eliminated by other species that are more competitive in those conditions. Spicebush is also not favored by deer for browsing (Lister and Widmann 2016). The extreme dominance of spicebush, and its prevalence throughout all topographic and moisture conditions, is a signature of major deer impacts that are affecting the species composition and structure of the understory.

After spicebush, 16 invasive species follow in the next tier of understory abundance, each species with an average of 1% to 7% relative presence where there is plant material. NNI species in the shrub layer (3'-10' ht.) cover 9% of the total forest area, and NNI species in the groundstory layer (0'-3' ht.) cover 25% of the GFLP forest floor. Pawpaw (*Asimina triloba*) has an important presence as the fifth most abundant species in the shrub layer (3' to <10'). Deer also do not typically eat pawpaw twigs and leaves (Lister and Widmann 2016). Native species other than spicebush and pawpaw each comprise 1% or less of the vegetated understory, and collectively total less than 8% of understory vegetation. In addition to very high deer pressure, this also indicates that significant competition from invasive exotic species is affecting the understory.

Snags and Coarse Woody Debris

Snags (standing dead trees) and CWD (dead tree branches and trunks on the ground) have very important wildlife value. The dead plant material directly supports a diverse food chain of insects, fungi, and bacteria that in turn support the birds, mammals, reptiles, and amphibians that feed on them. Snags and CWD also provide habitat structure. Large snags go through a series of wildlife associations as the wood continues to decay. Hawks use tall snags for nesting and perching. Primary cavity excavators such as woodpeckers create holes in large snags that are sometimes later used by secondary cavity user species such as owls and bats. Smaller birds such as black-capped chickadees nest in lower portions of snag cavities when upper portions have fallen or collapsed (DeGraff & Shigo 1985). Larger snags have habitat benefits over smaller snags, as large snags tend to stay upright longer to provide this series of wildlife associations over time.

The National Park Service (NPS) uses a forest assessment protocol for snags, (Tierney et al. 2014) for parks in the Northeast and Mid-Atlantic United States, that looks at total overstory snags and snags ≥12" DBH as a percentage of the total standing living and dead overstory trees. The three ratings for the snag metric from best to worst are: Good, Caution, and Significant Concern. The lowest rating of "Significant Concern" is given when less than 2 snags per acre ≥12" DBH are present. A rating of "Good" is given when at least 10% of total standing overstory trees are snags and at least 10% of total standing trees ≥12" DBH are snags. "Caution" is applied to conditions in between these ratings. GFLP as a whole falls just below the Good rating, with 9% of total standing trees ≥12" DBH as snags (see Appendix A, Table A-3: Snags and Coarse Woody Debris). Eight stands (Stands F, J, L, P, Q, T, U, and BB) have no snags ≥12" DBH. This condition is likely related to a combination of the stands' successional states, relative densities, and species compositions. Forest-wide, GFLP generally has few larger snags ≥18" DBH. Stands E, I, AA, CC, EE, and HH are important exceptions, ranging from 5 to 13 snags per acre that are ≥18" DBH. The larger snags in these stands are important for larger birds such as the pileated woodpecker, which requires snags ≥18" DBH for nesting (DeGraff & Shigo 1985).

The NPS also uses a forest assessment protocol for CWD (Tierney et al. 2014) that looks at CWD volume in relation to the aboveground volume of live overstory trees. Similar to the snag protocol, the NPS CWD protocol uses a Good, Caution, and Significant Concern rating system. A ratio >15% of CWD volume to live tree volume receives the highest rating of "Good." Only two stands (Stands G and P) fall below this threshold. While this is a high rating under the NPS CWD protocol, much of this CWD volume comes from smaller wood pieces ≤18" diameter. As with snags, larger diameter CWD has a high wildlife value as habitat structure for larger animals. CWD with a large DBH also has a greater likelihood that the material will persist longer before completely decomposing.

Forest Edges

GFLP has over 40 miles of forest edge, including where forest stand boundaries meet a change in landcover, and forest edges that are within stands (See Figure E: Forest Edge). Edge conditions at GFLP include where forest abuts neighborhoods at the edge of the park, roads and parking, paved trails (which were former vehicular roads), water courses, grass fields, and a future gas pipeline (see Table C: Edge Condition Summary). Forest edge effects as compared

to forest interior include differences in microclimate, nutrient cycling, and habitat suitability for flora and fauna (Forman 1995). The most obvious edge effect at GFLP is the concentration of NNI species observed at forest edges. Increased NNI seed deposition from wind and bird vectors, and higher solar exposure creates conditions favorable for establishment and expansion of highly competitive NNI flora.

3.4 Current Threats and Stressors

Pests and Diseases

Apparent effects of diseases and indications of forest pests were not directly observed during field work. However, the following are known to be present in Maryland and are of regional forest health concern.

Emerald ash borer (EAB) is a very serious pest of ash trees in Maryland, causing death of large trees within 3 years. The EAB can quickly invade entire stands of ash. The Maryland Department of Natural Resources (2017) notes that 100% mortality of ash trees is expected from this pest, unless a systemic pesticide treatment is used. White ash and green ash together make up 13% of the basal area of the forest, and an average of 35 trees/acre, or 13% of all trees at 10’ height or greater. Ash makes up over 50% of the understory trees between 3’ and 10’ in height in three stands (Stands A, G, and R) (see Appendix A, Table A-2: Understory and Ash Summary). It is also the most common seedling species <3’ in height across the forest. Ash therefore has a significant presence in the overstory and seedling layers, and an extensive EAB outbreak at GFLP would have a major impact on forest health, structure, and species composition.

Gypsy moth is a pest of many oak trees, causing large amounts of defoliation which may weaken but not necessarily kill the tree. As long-term loss of oak presence in forests is a regional concern in the Mid-Atlantic, widespread weakening of oak trees at GFLP will be a concern. The caterpillars are easiest to control with pesticide sprays during early to mid-May in Maryland.

Dutch elm disease is caused by a fungus infecting the vascular system of *Ulmus* species, including American elm. The disease is often spread by either native or European elm bark beetles. If caught early, treatments can include pruning off infected branches or injection of

Gwynns Falls

Forest Management Plan

Baltimore, MD

Figure E: Forest Edge

Legend

- 10 ft. Contours
- A — Forest Stands
- Forest Edge (50' wide)
- Future Forest Edge from Future Gas Line (50' wide)
- Buildings
- Property
- Streets
- Streams
- Waterbodies

0 500 1,000 1,500 Feet

N

Biohabitats

September 2017

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Table C: Edge Condition Summary

Stand	Forest Edge (ac.) (calculated at 50' width)	Park Boundary Neighborhood	Road or Parking	Paved Trail (former road)	Water Course	Grass Field	Future Gas Pipeline
Stand A	18.9	X	X		X		
Stand B	36.3		X	X	X	X	X
Stand C	20.6		X	X	X	X	
Stand D	39.3	X	X	X	X	X	X
Stand E	1.6	X	X		X		
Stand F	0.7	X	X				
Stand G	2.9	X	X	X			
Stand H	8.5	X	X	X		X	
Stand I	5.5	X	X	X			
Stand J	12.3	X	X			X	
Stand K	7.2		X	X			
Stand L	3.1	X	X				
Stand M	2.9	X	X	X		X	
Stand N	4.1		X	X			
Stand O	3.6		X	X			
Stand P	10.8	X	X			X	X
Stand Q	3.7		X			X	X
Stand R	7.0		X	X			X
Stand S	4.9			X			X
Stand T	2.5	X		X			X
Stand U	0.4		X			X	X
Stand V	1.3						
Stand W	4.5		X	X		X	

Table C: Edge Condition Summary (cont.)

Stand	Forest Edge (ac.) (calculated at 50' width)	Park Boundary Neighborhood	Road or Parking	Paved Trail (former road)	Water Course	Grass Field	Future Gas Pipeline
Stand X	1.8		X			X	X
Stand Y	3.1	X	X	X			
Stand Z	8.0	X	X				
Stand AA	0.9		X				
Stand BB	2.5		X				
Stand CC	2.6	X	X				X
Stand DD	2.4	X	X			X	
Stand EE	2.8	X	X			X	
Stand FF	4.5	X	X			X	X
Stand GG	3.5	X	X			X	X
Stand HH	9.9	X	X			X	

infected trees with systemic fungicides. An infestation of disease carrying bark beetles could have a moderate impact at GFLP. American elm comprises only 5% of the total forest basal area, but at 28 stems/ acre in the overstory, it ranks behind only American beech and the ash genus in abundance. One in 10 trees in GFLP at 10' in height or over is an American elm.

Oak decline is a condition where trees are weakened by environmental stress such as drought, waterlogging, frosts or by defoliating or sucking insects. Weakened trees are then invaded and killed by insects and diseases that cannot successfully attack healthy trees. The two major pests associated with oak decline are *Armillaria mellea* (Vahl: Fr.), a root disease commonly called armillaria root rot, and *Agrilus bilineatus* (Weber), the two-lined chestnut borer. Identifying and reducing associated stressors is key to preventing and treating this problem.

Oak wilt is caused by the fungus *Ceratocystis fagacerum* which attacks all oak species and has been found in 16 native oak species, but over 35 native and exotic oak species are susceptible as well as American chestnut, European chestnut (*Castanea sativa*), chinkapin oak (*Querus muehlenbergii*), tan oak (*Lithocarpus densiflorus*), and several cultivars of apple (*Malus* spp.). There is no cure for the fungus once inside the tree, so prevention of spread is the key to protecting trees in the forest. The USDA recommends addressing infected trees through a multistep process of trenching to break contact with neighboring tree roots and above ground wood removal.

Annelids

Earthworms consume and breakdown organic matter and aerate the soil but this can also alter the soil composition and structure causing excessive infiltration and doughtiness. Non-native earthworms are present in the soils of GFLP, and their impact is suggested in the limited amount of leaf litter recorded on-site. At this time, there is not an economically feasible treatment for dealing with the presence of these soil invertebrates.

Mammals

White-tailed deer have thrived in many urban and suburban areas of Maryland, as they prefer fragmented forest edge conditions, currently have no natural predators, and are generally not hunted in more highly populated areas. GFLP generally has a low number of tree seedlings, and an understory dominated by spicebush. A browse line, sightings of deer, and other signs such

as scat and rubs on trees indicate significant deer pressure on the forest, and likely overpopulation of deer beyond a healthy carrying capacity.

Non-Native Invasive Vegetation

Thirty-five species of non-native and invasive (NNI) plants were observed at GFLP, and all stands have some level of presence of these species. Along with deer impacts, NNI species present a major challenge to forest health and management. The presence of NNI species is pervasive. Only 3 of 186 plot clusters (cluster #180 in Stand M, cluster #370 in Stand AA, and cluster #431 in Stand CC) do not have NNI species. Norway maple (*Acer platanoides*) and tree-of-heaven (*Ailanthus altissima*) are the most dominant overstory invasive species, with six other NNI tree or large shrub species also present above 10' ht. Four stands (Stands J, O, P, and EE) have over 40 NNI trees/acre (see Table D: NNI Summary). Only six stands (Stands C, F, Z, AA, BB, and CC) have no NNI tree species observed in the overstory.

Twelve NNI shrub and herbaceous species are present in the 3' to <10' stratum with bush honeysuckle (*Lonicera* spp.), multiflora rose (*Rosa multiflora*), and oriental bittersweet (*Celastrus orbiculatus*) each averaging over 1% cover across the stands. Stand B is the most heavily invaded in this stratum with 30% ground area coverage of NNI species (see Table D: NNI Summary). Norway maple saplings are the only overstory tree species present in this stratum, with locations in three stands (Stands B, E, and HH).

The 0' to <3' height stratum has the highest richness and abundance of invasive species, with 24 shrub, vine, or herbaceous NNI species present in some combination in every stand at GFLP. Japanese honeysuckle (*Lonicera japonica*), Japanese stiltgrass (*Microstegium vimineum*), and oriental bittersweet are the dominant NNI species in this height class, each with over 3.5% ground area coverage average across the entire site. Porcelain berry (*Ampelopsis brevipedunculata*), garlic mustard (*Alliaria petiolata*), English ivy (*Hedera helix*), and dwarf periwinkle (*Vinca minor*) follow in dominance, each averaging over 1% ground area coverage. Stand A has the greatest NNI coverage in this stratum at 76% (see Table D: NNI Summary). Stand E has the lowest NNI ground coverage at only 1%, but also has a high tree/acre level of Norway maple in the overstory as noted above. Three NNI species, Norway maple, tree-of-heaven, and silktree (*Albizia julibrissin*), are present as seedlings. At least one of the three NNI species is present as seedlings in six stands (Stands A, B, D, I, T, and GG).

Table D: NNI Summary

Stand	Overstory Trees with Vines (Trees/ac.)	Native Overstory Trees with Vines (Trees/ac.)	NNI Overstory (Trees/ac.)	NNI >10' Tree Species	NNI Trees Understory (Trees/ac.)	NNI 3-10' % Cover	NNI <3' % Cover	NNI Understory Trees, Shrubs, Herbaceous & Vines Species
Stand A	286	240	13	paper mulberry, tree of heaven	50	10	76	English ivy, Japanese stiltgrass, winter creeper, multiflora rose, oriental bittersweet, garlic mustard, silktree
Stand B	118	115	1	Norway maple	15	30	39	porcelain berry, bush honeysuckle, multiflora rose, oriental bittersweet, Japanese honeysuckle, common periwinkle, Japanese stiltgrass, Japanese knotweed, European privet, English ivy, garlic mustard, Norway maple, silktree
Stand C	52	48	-	-	-	14	43	porcelain berry, European privet, Japanese knotweed, Japanese stiltgrass, bush honeysuckle, Japanese honeysuckle, multiflora rose, oriental bittersweet, celandine, English ivy, garlic mustard
Stand D	58	52	29	Norway maple, white mulberry, tree of heaven, Russian olive	14	3	26	porcelain berry, oriental bittersweet, multiflora rose, Japanese stiltgrass, common wormwood, Russian olive, bush honeysuckle, Japanese barberry, Chinese silvergrass, English ivy, porcelain berry, common periwinkle, Norway maple, silktree
Stand E	-	-	7	Norway maple	17	-	1	English ivy, Norway maple
Stand F	20	20	-	-	-	20	62	ground ivy, stinging nettle, bush honeysuckle, multiflora rose, wineberry, Japanese stiltgrass, Japanese honeysuckle, burningbush, Japanese barberry, oriental bittersweet, English ivy
Stand G	22	20	25	Norway maple	-	1	7	garlic mustard, bush honeysuckle, Japanese barberry, European privet, English ivy, oriental bittersweet, multiflora rose
Stand H	94	49	8	Norway maple, tree of heaven	-	6	7	bush honeysuckle, garlic mustard, multiflora rose, Japanese honeysuckle, English ivy, oriental bittersweet
Stand I	78	62	42	Norway maple, common buckthorn	60	12	21	bush honeysuckle, common periwinkle, Japanese honeysuckle, Japanese barberry, English ivy, oriental bittersweet, porcelain berry, Japanese wisteria, garlic mustard, multiflora rose, Norway maple
Stand J	63	53	50	Norway maple, common buckthorn	-	7	22	bush honeysuckle, English ivy, Japanese honeysuckle, common periwinkle, garlic mustard, multiflora rose, porcelain berry, Japanese wisteria, Japanese stiltgrass, oriental bittersweet
Stand K	130	111	10	Norway maple, tree of heaven, white mulberry	-	23	23	bush honeysuckle, Japanese stiltgrass, Japanese honeysuckle, multiflora rose, oriental bittersweet, porcelain berry, English ivy, garlic mustard, common periwinkle
Stand L	120	111	10	tree of heaven	-	5	16	bush honeysuckle, garlic mustard, wineberry, Japanese honeysuckle, English ivy
Stand M	9	7	7	Norway maple	-	1	3	oriental bittersweet, Japanese honeysuckle, garlic mustard, English ivy, multiflora rose
Stand N	20	20	3	Norway maple	-	2	14	Japanese barberry, Japanese honeysuckle, Japanese stiltgrass, wavyleaf basketgrass, oriental bittersweet, English ivy, bush honeysuckle, porcelain berry, garlic mustard, common periwinkle
Stand O	62	42	50	tree of heaven, Norway maple	-	14	60	Japanese stiltgrass, porcelain berry, oriental bittersweet, garlic mustard, Japanese honeysuckle, multiflora rose, wineberry, Japanese barberry, bush honeysuckle, common periwinkle, European privet, mile-a-minute vine, English ivy
Stand P	150	118	67	tree of heaven, Norway maple	-	3	25	Japanese stiltgrass, Japanese honeysuckle, English ivy, multiflora rose, wineberry, porcelain berry, oriental bittersweet
Stand Q	60	57	2	paper mulberry	-	7	22	Japanese stiltgrass, bush honeysuckle, mile-a-minute vine, Japanese honeysuckle, garlic mustard, English ivy, common periwinkle

Table D: NNI Summary (cont.)

Stand	Overstory Trees with Vines (Trees/ac.)	Native Overstory Trees with Vines (Trees/ac.)	NNI Overstory (Trees/ac.)	NNI >10' Tree Species	NNI Trees Understory (Trees/ac.)	NNI 3-10' % Cover	NNI <3' % Cover	NNI Understory Trees, Shrubs, Herbaceous & Vines Species
Stand R	39	36	3	tree of heaven	-	22	40	bush honeysuckle, multiflora rose, oriental bittersweet, Japanese honeysuckle, garlic mustard, Japansese stiltgrass, mile-a-minute vine, European privet, English ivy, porcelain berry, Japanese barberry, common periwinkle
Stand S	37	37	3	princess tree, Norway maple	-	2	17	Japanese honeysuckle, common periwinkle, oriental bittersweet, multiflora rose, Japanese stiltgrass, English ivy, Japanese barberry, garlic mustard
Stand T	2	2	14	Norway maple	40	-	5	oriental bittersweet, Japanese honeysuckle, English ivy, common periwinkle, Norway maple
Stand U	60	56	8	Norway maple, white mulberry	-	-	4	English ivy, oriental bittersweet, Japanese honeysuckle
Stand V	40	36	7	Norway maple	-	2	7	Japanese honeysuckle, English ivy, bush honeysuckle, oriental bittersweet, multiflora rose, garlic mustard
Stand W	38	32	25	paper mulberry, Norway maple, bush honeysuckle	-	14	22	multiflora rose, garlic mustard, English ivy, Japanese honeysuckle, bush honeysuckle, porcelain berry, wineberry, Japanese wisteria, Japanese stiltgrass, oriental bittersweet
Stand X	-	-	2	princess tree	-	-	18	oriental bittersweet, Japanese stiltgrass, Japanese honeysuckle, English ivy, common periwinkle, multfora rose
Stand Y	8	7	1	Norway maple	-	-	5	Japanese stiltgrass, oriental bittersweet, English ivy, Japanese barberry, common periwinkle
Stand Z	10	10	-	-	-	-	17	Japanese barberry, oriental bittersweet, English ivy, porcelain berry
Stand AA	-	-	-	-	-	-	6	oriental bittersweet, Japanese stiltgrass, English ivy, garlic mustard
Stand BB	18	18	-	-	-	-	13	Japanese stiltgrass, oriental bittersweet, English ivy, Japanese honeysuckle, garlic mustard
Stand CC	-	-	-	-	-	-	4	oriental bittersweet, English ivy, bush honeysuckle
Stand DD	-	-	2	Norway maple	-	12	25	oriental bittersweet, bush honeysuckle, European privet, Japanese stiltgrass, garlic mustard, mile-a-minute vine, wineberry, English ivy, multiflora rose
Stand EE	30	17	43	white mulberry, Norway maple	-	3	29	common periwinkle, Japanese stiltgrass, oriental bittersweet, European privet, English ivy, porcelain berry, bush honeysuckle, kudzu, mile-a-minute vine
Stand FF	-	-	6	Norway maple	-	5	25	oriental bittersweet, bush honeysuckle, Japanese barberry, Japanese honeysuckle, English ivy, Japanese stiltgrass, multiflora rose
Stand GG	-	-	14	tree of heaven, Norway maple, white mulberry	18	24	39	bush honeysuckle, oriental bittersweet, Japanese honeysuckle, Japanese stiltgrass, garlic mustard, European privet, multflora rose, English ivy, porcelain berry, wineberry, tree of heaven, Norway maple
Stand HH	-	-	20	tree of heaven, Norway maple	25	14	41	garlic mustard, Japanese honeysuckle, multiflora rose, oriental bittersweet, wineberry, Japanese stiltgrass, Norway maple
Stand Area-Weighted Average	**47**	**40**	**14**		**7**	**9**	**25**	

Vines also are having an impact on overstory trees in the park. Five stands (Stands A, B, K, L, and P) have over 100 trees/acre with NNI vines (see Table D: NNI Summary). Conversely, eight stands (Stands E, X, AA, CC, DD, FF, GG, and HH) have no trees observed with vines on them.

Forest edges predictably contain higher concentrations of NNI species than the adjacent forest interior. Figure E: Forest Edge illustrates the edge locations of each stand in GFLP. The depth of edge effects into forest patches can vary significantly by type of effect, shape and orientation of the edge, and conditions of the surrounding landcover (Forman 1995). Based on qualitative observations at GFLP, 50' is used as an estimated average for the distance of heavy NNI infestation from forest edges. Few sample plots were located in the edge areas for each stand, so estimations of NNI density are calculated separately for the edge compared to the main stand. These numbers are used to quantify additional effort needed to treat NNI species in the forest edge.

Appendix A, Table A-4: NNI Species Observed at GFLP presents a list of NNI species organized by growth form. The table also identifies a NatureServe Invasive Species Impact Rank (I-Rank) for species available in their database. The I-Rank assesses the NNI species impact based on ecological impact, current distribution and abundance, trend in distribution and abundance, and management difficulty (Morse et al. 2004, NatureServe 2017). Appendix B includes additional mapping by stand of NNI steps per acre for trees and percent cover for understory plants.

Refuse

Refuse (trash and debris) is pervasive throughout GFLP, present to some degree in 80 of 186 plot clusters, or 43% of plot clusters. Trash is transported via the storm drain system and waterbodies into the floodplain forest and blown into the upland forest from surrounding communities. Years of illicit dumping have also accumulated refuse throughout GFLP.

Mosquitos can breed in as little as a few centimeters of stagnant water and can carry a variety of diseases that pose a risk to human health (e.g. West Nile virus, Zika virus, etc.). Where stagnant water collecting in debris is present at forest edges and adjacent to residential communities, mosquitos can be a health concern.

3.5 Future Threats and Stressors

Pests and Diseases

Asian long-horned beetle (ALB) is not yet known to exist in Maryland but could be a significant future threat, as ALB is known to attack 29 species of deciduous hardwood trees. ALB prefers species of maple (*Acer* spp.) including boxelder, Norway, red, silver, and sugar maples. Other known hosts include alders (*Alnus* spp.), birches (*Betula* spp.), elms (*Ulmus* spp.), horse chestnut (*Aesculus* spp.), poplars (*Populus* spp.), sycamore (*Platanus* spp.) and willows (*Salix* spp.). Species that could be affected at GFLP by this potential future pest total 10% of the overstory basal area and 18% of the cumulative overstory trees/acre. With nearly 1 in 5 overstory trees that could be susceptible, this potential future pest could be a major threat to forest health and needs to monitor.

Beech bark disease (BBD) is not yet known to exist in Maryland but occurs in the surrounding states of Pennsylvania, West Virginia and Virginia and has potential to be a major threat if spread continues. The beech scale insect is the vector for the *Nectria* fungi which causes this disease. Control in forest stands would likely cost prohibitive, and early detection and salvage cuttings are the only present forest control.

Climate Change

Climate change effects on the health of the urban forest is not definitively known, but it is predicted that impacts will be realized. Predicted impacts include shifts in average temperature range, lack of or reduced winter freezing temperatures (increased pest populations), precipitation changes (both amount and storm intensity), and new or expanded pest and disease range.

4 MANAGEMENT RECOMMENDATIONS – GENERAL

Based on the field assessment and data analysis conducted for GFLP, Biohabitats has determined that the forests in GFLP are comprised largely of central Appalachian hardwood tree species. In most cases these urban forests are dominated by large trees, although their presence is often highest in the forest core with edges being dominated by non-native invasive trees, shrubs, vines and herbaceous plants. Management actions within GFLP stands should promote native vegetation diversity and ameliorate disturbances caused by human, deer, and invasive species impact. Much of the urban forest is heavily infested with vines species such as English ivy and Oriental bittersweet that climb the trees, eventually killing them. In other areas of the forest, mature trees are aging, damaged by storms, and are lacking replacement in the form of native regeneration. In addition, there are several insect and fungal pests that are known to infect trees, such as ash and oak, that can weaken or kill trees in the GFLP forest stands. The size, density and species of trees within a given stand varies depending on the location, age of stand, and past management actions.

There is need for five (5) general management activities within the management areas. Each management category is not necessarily independent from the others and in some cases more than one are recommended to effectively achieve the desired results. The management activity recommendations include:

- Vegetation Management
- Soils Management
- Deer Impact Management
- Refuse Management
- Adaptive Management

4.1 Vegetation Management

Integral in working towards the City's goal of improving the ecological integrity of the GFLP forests and increasing the tree canopy, a variety of vegetation management tasks should be employed. In areas where natural regeneration is limited by invasive plant species or deer browse, artificial regeneration (planting) may be used if the site is prepared prior to planting. Site preparation could include removal of invasive understory vegetation, control of the initial growth of invasive species, and the piling, chipping, and spreading of woody debris to improve soils.

Forest NNI vegetation management may expose soils that would be prone to erosion. Best management practices and erosion control measures should be implemented, where appropriate, for projects in GFLP. Opportunities for the augmentation of natural regeneration are present but only with the establishment of individual tree protection or deer exclusion areas. There are four main components to the overall management of vegetation at GFLP:

- Non-Native Invasive Plant Management
- Stand Thinning and Tree Removal
- Tree Regeneration Establishment and Survival
- Non-Native Invasive Plant Monitoring

4.1.1 Non-Native Invasive Plant Management

Some areas of the park are heavily invaded, while others contain only a few NNI plants. However, many aggressive NNI plants that grow in full shade have penetrated the undisturbed forest interior. They are displacing native trees, shrubs, and saplings and limiting the regeneration and growth of native trees and plants, which threatens both the ecological health and sustainability of GFLP. Regionally, the growth and spread of these NNI species, which had been slowly increasing over the past century, rapidly expanded over the last 30 years. The problem is particularly severe in urban parklands with frequent disturbances and extensive edges (GFLP has an estimated minimum of 40 miles of edge), which increase the spread of invasive plants. During this project, Biohabitats documented the presence of 35 NNI species in GFLP.

Management of invasive vegetation will be required in most stands to promote and maintain urban forest health. The following is a comprehensive management plan that:

- Prioritizes invasive plant control strategies to protect mature woodlands and trees in the park's most biologically diverse and important areas.
- Employs techniques for early detection and rapid response for control of new invasive species.
- Provides for restoration of priority areas.

4.1.1.1 Control Strategies

Before considering implementation of any control strategy, staff must consider four key components:

- Selectivity
- Timing
- Type of Plant
- Type of Control

4.1.1.1.1 Selectivity

It is extremely important, when determining the best control methodology, to consider that desirable species co-exist in many of the control areas at differing amounts. Utilize NNI density measurements and percent cover or stems/acre measurements of natives collected in this plan to choose the methodology most appropriate for management. All variables should be considered prior to choosing a control methodology. When determining the best methodology to control an invasive plant, it is important to consider several variables, including whether the target species are located in:

- Natural area or forest interior
- Rights of way
- Landscaped area around facilities
- Floodplain or drainage
- Heavily disturbed or high use area
- Areas near roads/trails or water sources
- Erosive soils or steep terrain

4.1.1.1.2 Timing

Timing invasive plant control projects properly can make the difference between a 99% mortality rate and a 10% mortality rate. Generally speaking, the best seasons to treat NNI plants in descending order of preference are:

- *Fall:* Fall is the best season for controlling many persistent or tardily deciduous NNI plants. In the fall plants are sending their resources back into the root system in late August through November. This is an ideal time to send an herbicide into action.
- *Summer:* During the hottest days of summer, most herbicide methods, with a few exceptions, are very effective. Being selective is more difficult this time of year because both desirable and undesirable plants are in full bloom. Also, there is the threat of drought which could hinder translocation of chemical.

- *Winter:* Winter is a good time of year to treat multi-stemmed and evergreen vine species. Herbaceous species are usually dormant now and tree species will not react as well to herbicides in the winter. Multi-stemmed and evergreen vine species' smaller root systems allow certain "winter" herbicides to be relatively effective during the colder months.
- *Spring:* Spring is generally the worst time of year to treat many NNI plants when using herbicides. This is because the plants are sending resources out, effectively slowing down and disturbing herbicides in action. Most NNI plants show their foliage a month or so before natives making easier targets. Spring is the best time to work on several herbaceous plants, i.e. Japanese stiltgrass.

4.1.1.1.3 Type of Plant

The following recommendations are general and are broken down according to plant type (unless otherwise indicated): Woody Plants: trees, shrubs, and vines; Herbaceous Plants: forb, herb, and graminoid material. Due to the invasive character of these plants, a five to ten-year maintenance program should be put into place with regular monitoring for an indefinite time period.

Woody Plants: Trees, shrub and vines can be managed mechanically by grubbing, pulling, mowing or girdling; or chemically by foliar application, basal bark application, stem injection, or cut stem application.

Herbaceous Plants: Herbaceous forbs and grasses can be managed by mechanically pulling, grubbing or mowing; or chemically by foliar application or pre-emergent application.

4.1.1.1.4 Type of Control

To sustain viable and healthy forest ecosystems it is necessary to consider vegetation management practices. Successful vegetation management uses a systematic approach called Integrated Pest Management (IPM), or in this case Integrated Vegetation Management (IVM). Integrated Vegetation Management (IVM) practices reduce the need for pesticides, promote healthy ecosystems, and provide measurable results, such as greater natural species diversity within the forest and better control of invasive species. Control options for IVM may include techniques such as:

- Mechanical/Manual
- Chemical
- Cultural
- Biological

Prescribed fire in the form of controlled burns is used by some resource managers for managing woodland conditions and improving ecological health. Although not a primary recommended tool for this highly urban parkland site, prescribed fire is a management measure that the City can perform as a controlled pilot test for a discrete and carefully selected pilot demonstration are (e.g., a half- to one-acre area with few non-target impacts and a means to readily isolate the burn area).

Mechanical Methods

Mechanical control of NNI plants includes using tools such as chain saws, brush cutters, shovels, weed wrenches, mattocks and sometimes larger machinery (mowers, tillers, mulchers). Care should be taken to evaluate the collateral damage that may be caused by such equipment prior to selecting this methodology. While large machinery is sometimes used to control invasive species. Such equipment is not selective and is used under heavy infestation control environments. Light mechanical methods are sometimes effective in sensitive areas. Weed wrenches and mattocks are excellent tools for volunteers and staff alike to grub out multi-stemmed species such as bush honeysuckle and privet located in the forest interior. Mechanical control is most effective when utilized in the maintenance stages of a project, after initial treatment when overall densities have been reduced. Methods include:

- Cutting
- Girdling
- Mowing
- Hand Pulling
- Grubbing

Chemical Application Methods

Chemical management methodologies range from aerial foliar applications of herbicide to needle injections or painting of herbicide into cut stems or stumps. The methods listed below

are general and more specific recommendations should be determined by the targeted herbaceous, shrub, vine, and tree species.

***All herbicides should be applied in accordance with specific label instructions, which include personal protective equipment, storage requirements, and applicable laws.** Herbicides are often selected in combination with mechanical methods of controlling NNI plants. Prior to using any herbicides, a detailed analysis of the chemical components of the herbicide and its effects on the environment are considered. An impact assessment is conducted which determines whether the ramifications of chemical control override the biological pitfalls of invasive plants. Selection of herbicides for chemical control is based on the species being managed, landscape position and proximity to sensitive features (e.g., wetlands and waterways), manufacturers labels and instructions, and applicable laws. Methods include:

- Foliar
- Cut Stem
- Basal Bark
- Pre-emergent
- Stem injection

4.1.1.2 Cultural

A few sites visited across GFLP currently have a limited presence of NNI plants. In these locations, prevention of establishment is a multi-faceted cultural tool that can be implemented in a cost-effective manner within the City. As a municipal land management entity, the City can practice management strategies within and adjacent to GFLP that minimize opportunities for NNI plant populations to become established and to expand into new un-infested areas. A key to prevention is regular monitoring for new invasions. A list of recommended Best Management Practices (BMP's) related to City Park operational practices is also provided in Appendix A.

Outreach is a logical avenue for the City to pursue in implementing prevention. Invasive species do not respect legal property boundaries and land management activities of park neighbors and user groups will directly impact the sustainability of GFLP ecosystems. While outreach recommendations to GFLP neighbors and user groups were outside of the scope of this project, it is strongly recommended that the City pursue these initiatives to protect target stand resources.

4.1.1.3 Biological

Grazing by domestic livestock and white-tailed deer is a form of biological control. Livestock and deer grazing on palatable interfering vegetation can control some species but rarely results in eradication. Most livestock species are preferential grazers meaning they select the most palatable species first. In GFLP, deer already browse the most desired tree species from the forest and have shifted species composition towards less desirable NNI plants. Using goats to control interfering plant species in forest areas has met with some success and has been used previously in Baltimore City.

4.1.1.4 Prioritization

As it relates to the management of the forests within GFLP, prioritization was mainly determined by the presence and concentration of NNI vegetation within each stand. While it may seem important to treat the worst condition stands as priority and get the invasives under control, research suggests that focusing efforts on low density areas may be more effective at reversing the spread (see Figure F) (WI DNR 2016). Efforts can move towards the highest concentration areas after eliminating the sources of NNI plants in more pristine areas of forest.

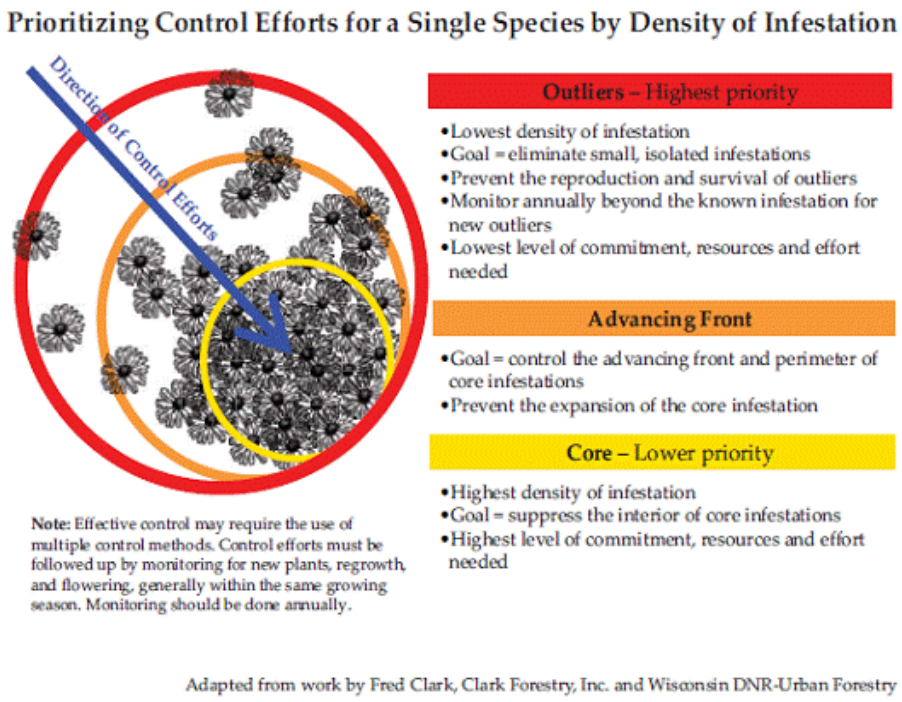

Figure F: Prioritizing control for a single NNI species by density of infestation (WI DNR 2016).

4.1.2 Stand Thinning and Tree Removal

The mature forests within GFLP should be maintained with a basal area per acre of between 70 and 110 square feet with an average tree diameter of 18". This range encompasses most of the existing areas within GFLP, however several stands exist in an overstocked or understocked condition. Given current conditions, it is recommended that the focus of management activity should be less on stand thinning of desirable species but removal of NNI canopy components. Girdling is the recommended method of treating NNI canopy trees to increase the ecologically beneficial effects of standing woody debris. Considerations should be made regarding proximity of standing material to actively used trails, roads, and buildings assets. Standing dead trees within a potential target range of an asset should be considered hazardous and should be felled. Thinning of desirable species, without addressing the significant NNI conditions, would likely allow NNI species to gain a stronger foothold. Conditions should be re-evaluated near the end of the 10-year period covered by this management plan to determine if conditions for canopy thinning are present.

Management of the stands will be driven primarily by opportunities created by the natural aging of the stand, or other natural factors that affect the health of the urban forest (e.g., windthrow, disease, insects, invasive species), and will focus on improving and maintaining the health of each stand. For example, if trees in the stand become infected with a disease, tree removal activities should be conducted to remove the trees to improve forest health and prevent the spread of the disease to other trees in the stand. In some cases, to achieve the management goals, periodic removal of trees in the GFLP urban forests may be required. To promote forest health, removal of trees should focus on the removal of NNI trees, dead or dying trees, trees with disease or insect infestations, and storm-damaged or hazardous trees.

4.1.3 Tree Regeneration Establishment and Survival

An assessment of the condition of the canopy and a survey for opportunities to plant new trees or encourage natural regeneration was conducted as part of this plan. Forest stand canopy cover ranges from 20% to 88% and additional non-forested areas are present in several stands. Most of the forest canopy gaps have potential for establishing regeneration after treatment for NNI vegetation. To the extent possible, it is recommended that trees and shrubs be installed in urban forests to promote species diversity and improve wildlife habitat. The diversity of species that will grow in the understory and in gaps will be limited by canopy density, understory density

and species composition, soil conditions, and the litter layer of the particular stand. Certain species, specifically American beech and black walnut (*Juglans nigra*), suppress growth and survival of many species in the area near them. However, some species such as native oaks, hickories, and cherries (*Prunus* spp.) may survive in gaps. These trees provide wildlife habitat, and if planted in openings will enhance structural diversity in the forest. Based on observations of current plant distribution, American beech, white ash, and green ash appear to be the most tolerant of conditions in the understory. These species will improve wildlife habitat structural diversity where the urban forest canopy is dense.

Species recommendations for trees, shrubs, and herbaceous plantings in stands under three potential hydrologic regimes (floodplain, mesic, upland) are provided in Appendix A, Table A-5. Their recommended use for either new afforestation plantings or as existing forest enhancement plantings are also indicated in the table.

4.1.4 Non-Native Invasive Plant Monitoring

Monitoring is a critical, yet often neglected aspect of NNI plant management due to lack of funding. Without routine monitoring of the changes in plant composition on a treatment site, it is impossible to determine if the ultimate goal of a desirable complex of native plants has been achieved, and if the techniques used have been effective. Research suggests that concurrent or post-treatment planting of native trees and shrubs followed by regular monitoring and intervention enhances the forest restoration efforts, increasing overall native diversity and sustainability (Simmons et al.,2016)

A monitoring program need not be a labor-intensive undertaking, it could be as simple as a visual estimate of the invasive plant species present and their respective abundance as a percentage of the vegetative cover. This effort is well-suited to the use of a combination of staff, contractor and/or volunteer participants as it does not require difficult manual labor or the use of specialized equipment. A comprehensive monitoring plan to protect existing trees and plant new trees, with annual, or at a minimum, five-year reports on the ecological health of the park is recommended. For a more comprehensive forest system evaluation the sample plots from this study (see Appendix B, Figure B-1: Sample Plot Locations) can be periodically re-sampled and evaluated (i.e. 5-10-year cycle). Cyclical monitoring schedules can be established for each of the management areas. Heavily invaded stands, disturbed sites, or newer plantings should be

monitored more frequently than stable stands with few NNI plants and older established plantings.

4.1.5 Pest and Disease Monitoring

Other monitoring programs that focus on the regional status of common forest pests and diseases are conducted through the MD Department of Agriculture Forest Service and MD DNR-Cooperative Forest Health Program, a resource invaluable to Baltimore City. Continued communications with state agencies are essential to prevention, early detection and treatment of potential threats to the large urban forest of GFLP. Current monitoring relevant to this park includes: Southern Pine Beetle, Sirex wood wasp and Walnut Twig Beetle.

4.2 Soils Management

Baltimore is divided nearly equally along a boundary between two physiographic provinces of parent material- GFLP sets specifically upon the Piedmont Plateau. The City of Baltimore Soil Survey of 1998 indicates that soils in the Piedmont Plateau of Baltimore are very deep, moderately sloping, well-drained upland soils underlain by semi-basic or mixed basic and acidic rocks (Yesilonis et al. 2008).

All sampling plots within GFLP exhibited minimal amounts of organic litter on the forest floor. No stands showed more than 0.8” litter depth and many had only bare ground. The alteration of microclimatic conditions within the forest is profound due to lack of a robust organic surface layer. Much of this is likely due to the presence of invasive earthworms that process materials at very high rates. Effects of reduced leaf litter include:

- Increased soil temperatures
- Decreased soil moisture
- Reduced decomposition of coarse woody debris

Repairing and improving the forest soils condition within GFLP is a long-term endeavor. Studies have shown that the addition of compost and mulch to forest soils as part of restoration activities improves the growth and survival of planted native trees and shrubs while also suppressing the growth of NNI vegetation. Adding compost or mulch also:

- Protects the soil from erosion
- Increases soil organic matter content

- Reduces compaction from the impact of heavy rains
- Conserves moisture, reducing the need for frequent watering of plantings
- Maintains a more even soil temperature
- Prevents weed/NNI growth

The form and composition of the compost should not be so nutrient available that it fuels NNI vegetation. While spreading mulch into remote and steep locations is less feasible, the addition of surface-applied mulch to recently treated or planted stands should be a management goal. One approach used elsewhere to stimulate soil fungi, and improve soil health, is to apply a thin layer (no more than ½ inch) of raw green mulched wood chips to bare soil areas. It has been demonstrated that when applied to the forest floor, woodchip mulch can beneficially affect the species richness, composition, and percent native cover of understory plant species, and it may promote forest restoration.

4.3 Deer Impact Management

Deer Management Plan

There is evidence that an overabundant white-tailed deer population is damaging the forest in GFLP. To address this situation, it is recommended that the City develop a deer management strategy that supports long-term protection, preservation, and restoration of native vegetation. Such a strategy would need to address City policy issues, public sensitivities, and be comprehensive for other City parks.

Based on the January 2015 USDA-APHIS report for GFLP, the extrapolated deer population density was 53.68 deer per square mile. Studies from forests in the region similar to GFLP, suggest that populations higher than 5-10 deer per square mile will impact successful oak-hickory forest regeneration in the park (NPS 2011). The deer concentration in GFLP is far outside the healthy biological and cultural thresholds for the region. In similar parks, it is estimated to take five or more years from the start of deer management operations for vegetation growth to recover to the point where forest regeneration is sustainable (NPS 2011). A variety of deer management options are available at varying rates of success and cost. These include, but are not limited to:

- Woven wire fence deer exclosures
- Planting cages for groups of planted material
- Plant cages for individuals

A deer management plan, with ongoing deer population surveys, is recommended for GFLP. In the interim, it is recommended that planting cages are used and several pilot scale deer exclosures be established to demonstrate the impacts of deer in GFLP forests. Associated estimated planning level costs for an initial survey and deer exclosures are provided.

The following management options for protecting vegetation from deer impacts are all considered effective but are listed here in order of least to greatest potential installation expense and maintenance costs.

Planting Cages

In areas containing landscape plantings, new restoration plantings, or rare plant species, the City should consider caging of individual plants and small groups of plants to protect them from deer browsing. The caging used would be limited to the immediate area around the plants to be protected, typically less than 45 square feet total, and would consist of a 5-foot-high, woven wire fence (typically a 1-inch by 2-inch mesh), with netting or other covering over the top as appropriate. Cost estimates provided for vegetation plantings include tree and shrub cages.

Large Exclosures

In addition to the small protective caging that would be installed in select areas, large exclosures would further allow reforestation. While a large deer exclosure is defined as a fenced area of more than 5 acres constructed for the purpose of excluding deer from entering, it would benefit the City to establish smaller exclosure areas to serve as a demonstration of their effectiveness on-site. The deer exclosures would be a minimum of 8’ high and would consist of woven wire with 3” to 4” openings to allow some small animals to move freely through the fence. Metal posts would be placed approximately every 20’ along each side of the exclosure, with pressure-treated 4” by 4” wooden posts set in concrete as corner supports.

Deer would be driven out of the exclosures before completion. Visitors would not be able to use the areas included in the exclosures during or after construction for approximately 10 years. A

visual inspection would need to be performed once a month and after storm events. Maintenance on the exclosures would be performed on an as-needed basis, but a minimum of four times a year. If deer are found within an exclosure, they would be removed, as would any other animals that appeared to be trapped within the exclosure, and repairs made as needed. Most exclosure types are built with deer release or maintenance access gates.

It has been suggested that the minimum area that would need to be fenced at one time to meet forest regeneration goals would be from 5% to 10% of the forested area (NPS, 2011). Based on this, up to 10 large exclosures of various configurations would need to be constructed to fit the landscape, each covering from about 5 to 10 acres or up to a total of approximately 80 acres. The exclosures would be initially located throughout the park, with their locations based on several criteria: ease of access, compatibility with the park's topography and current trails systems; and the absence of steep slopes. Areas containing valuable habitats (i.e., areas that are diverse, sensitive, free of invasive plants, and/or relatively pristine) would be targeted for protection. Potential deer exclosure locations are shown in Figure G: Potential Afforestation & Deer Exclosures.

Material and installation costs are estimated at $9 per linear foot of fence. It is estimated that approximately 20,210 linear feet of fence would be needed to construct the 10 large exclosures, and that it would take up to 70 working days to construct all exclosures for a total cost of $182,000. Exclosures would be relocated approximately every 10 years. Costs for this are estimated at 75% of the original cost to install the exclosures. Maintenance costs could be substantial due to the remoteness of some exclosures and potential vandalism. Annual labor to inspect and maintain fences is estimated at approximately 24 days with 2 staff, which would occur over four visits per year. Using an average hourly rate of $20/hr for the two staff and 24 days to cover all of the exclosures per visit, the annual maintenance cost would be $18,000 for labor. An additional $10,000 per year would be needed for maintenance materials and additional visits due to storm damage. Monthly inspections would add another $3,800 annually.

4.4 Refuse Management

There are many areas within GFLP that contain trash and debris that has been dumped or has blown in from the surrounding neighborhoods. While the refuse is an aesthetic issue and potential mosquito breeding habitat, there is not much to indicate that refuse impacts to the

ecological health or sustainability of the forest communities of the park are severe. Therefore, any management activities related to refuse within the park should be considered incidental to any other management activities. Trash and debris removal is a good candidate for volunteer stewardship clean-up days and activities. As the presence of large pieces of trash (old cars, tires, appliances, etc.) could hinder the operation of some mechanized equipment used to treat NNI plants and conduct planting (mowers, mulchers, tillers, spades, etc.), Biohabitats has noted several locations where debris are large and/or abundant. In recent communications, researchers at the Baltimore Ecosystem Study (BES) expressed interest in working with the City in these locations to collect data regarding mosquito activity.

4.5 Adaptive Management

Process Framework

The possible situations that may arise over the course of a 10-year plan period cannot all be accounted for during the planning process. Actions and plans will need to be adjusted over time and by continually monitoring the urban forest, observations and collected data can be used to make these adjustments. Adaptive management is a systematic, practical approach to improving resource management policies and practices. It provides a structured process for learning which actions best meet management objectives, and for reducing resource management uncertainty.

Adaptive management promotes flexible decision making that can be adjusted in the face of uncertainties, as outcomes from management actions and other events become better understood. Some of the characteristics of adaptive management include monitoring analysis of the treatment outcomes in consideration of the original objectives, and incorporation of the results into revised treatment decisions.

Regular monitoring can reveal new issues that were not addressed in the plan. For example, the introduction of a new NNI plant species, pest, or disease could require changes to the plan. New management goals or objectives may need to be added, with corresponding actions and monitoring. By providing for regular evaluation and revision of the plan as part of the ongoing management process, the need for change can be identified before a crisis develops.

Gwynns Falls
Forest Management Plan

Baltimore, MD

Figure G: Potential Afforestation & Deer Exclosures

Legend

- 10 ft. Contours
- Potential Afforestation Areas
- Potential Deer Exclosure Areas
- GFLP NE — Management Units
- A — Forest Stands
- Buildings
- Property
- Streets
- Streams
- Waterbodies

0 500 1,000 1,500 Feet

N

Biohabitats

October 2017

Document Path: W:\GIS\PROJECTS\16029.01 GFLP Forest Management Plan\MXD\ReportMaps_FINAL\G_Potential_Afforestation_Deer_Exclosures.mxd

Monitoring and action intervals for each management activity over the plan's 10-year timeframe are presented in Table E. Costs for monitoring have been incorporated into the costs for each management activity.

Table E: Monitoring and Action Intervals

	Inspection Interval						Action Interval					
	Weekly	Monthly	Quarterly	Semi-Annual	Annual	Bi-Annual	Weekly	Monthly	Quarterly	Semi-Annual	Annual	Bi-Annual
Non-Native Invasive Plant Management												
Priority 1					YEAR 1-5	YEAR 5-10			YEAR 1-5	YEAR 5-10		
Priority 2				YEAR 1-5	YEAR 5-10				YEAR 1-5	YEAR 5-10		
Priority 3			YEAR 1-5	YEAR 5-10					YEAR 1-5	YEAR 5-10		
Reforestation												
Priority 1				YEAR 1-2	YEAR 3-5	YEAR 5-10			YEAR 1-2	YEAR 3-5	YEAR 5-10	
Priority 2			YEAR 1-2	YEAR 3-5	YEAR 5-10			YEAR 1-2	YEAR 3-5	YEAR 5-10		
Priority 3			YEAR 1-2	YEAR 3-5	YEAR 5-10			YEAR 1-2	YEAR 3-5	YEAR 5-10		
Afforestation												
Priority 1		YEAR 1	YEAR 2-5	YEAR 5-10			YEAR 1	YEAR 2-5		YEAR 5-10		
Priority 2		YEAR 1	YEAR 2-5	YEAR 5-10			YEAR 1	YEAR 2-5		YEAR 5-10		
Priority 3		YEAR 1	YEAR 2-5	YEAR 5-10			YEAR 1	YEAR 2-5		YEAR 5-10		
Deer Exclosures												
Priority 1		YEAR 1-10							YEAR 1-10			
Priority 2		YEAR 1-10							YEAR 1-10			
Priority 3		YEAR 1-10							YEAR 1-10			

5 MANAGEMENT RECOMMENDATIONS – STANDS

Table F summarizes the proposed management activities and associated parameters within each stand, to be used in planning necessary actions. Within the 34 forest stands that were delineated and described in Section 3.3 of this Plan, the majority will receive NNI vegetation management with associated reforestation. Other areas with potential for increasing the urban tree canopy of GFLP are currently open, grass dominated areas adjacent to existing forest that can be afforested (see Figure G: Potential Afforestation & Deer Exclosures). A few stands have large areas of accumulated trash that could be removed over time and several stands could receive large demonstration deer exclosures.

Stand A

Acres: 23.0
Location: Dickeyville-Purnell Management Unit
Forest Type: Mixed Floodplain Hardwoods
Dominant Canopy Species: white oak, American elm, boxelder

This sensitive stand contains all floodplain and associated wetlands on both sides of the river along the northern end of the Gwynns Falls as it occurs in GFLP. Opportunities for afforestation (~1.6 acres) occur along the edges of the open mowed greenspace in Dickeyville near the dam and a small opening at the turnaround at the gate on Wetheredsville Road. The open understory in the floodplain forest should be addressed through underplanting and filling canopy gaps with native species. The planting should be completed in conjunction with invasives control measures. This stand has the highest concentration of trees with vines in the canopy. As with the other floodplain stands, it has a high level of NNI presence, and a significant area over 15% slope, which is sensitive to erosion during NNI management (see Table A: Stand Summary).

Stand B

Acres: 40.3
Location: Gwynns Falls Floodplain Management Unit
Forest Type: Mixed Floodplain Hardwoods
Dominant Canopy Species: tulip poplar, sycamore, eastern cottonwood

This sensitive stand contains all floodplain and associated wetlands on both sides of the river along the middle section of the Gwynns Falls as it occurs in GFLP. With only 53% canopy closure, opportunities for reforestation are present, specifically along the left bank floodplain near the confluence with Dead Run. The open understory in the floodplain forest should be addressed through underplanting and filling canopy gaps with native species. The planting should be completed in conjunction with invasives control measures. This stand has a large number of trees with vines in the canopy. As with the other floodplain stands, it has a high level of NNI presence, and a significant area over 15% slope, which is sensitive to erosion during NNI management (see Table A: Stand Summary).

Stand C

Acres: 24.6
Location: Gwynns Falls Floodplain Management Unit
Forest Type: Mixed Floodplain Hardwoods
Dominant Canopy Species: green ash, boxelder

This sensitive stand contains all floodplain and associated wetlands along the southern end of the Gwynns Falls as it occurs in GFLP. Opportunities for afforestation (~4 acres) occur along the edges of the playing fields in the Leon Day Park. The open nature of the understory in the floodplain forest should be addressed through underplanting and filling canopy gaps with natives. Management objectives for this stand should be to treat invasives and to plant native species. As with the other floodplain stands, it has a high level of NNI presence, and a significant area over 15% slope, which is sensitive to erosion during NNI management (see Table A: Stand Summary).

Stand D

Acres: 44.4
Location: Gwynns Falls Floodplain Management Unit, at Dead Run
Forest Type: Mixed Floodplain Hardwoods
Dominant Canopy Species: sycamore, tulip poplar, green ash

This sensitive stand contains all floodplain and associated wetlands along Dead Run as it occurs in GFLP. Opportunities for afforestation exist in the open grass area southeast of the Ben Cardin Pavilion. The open nature of the understory in the floodplain forest should be

Table F: Management Activity Summary

Management Unit	Stand	Forested Area (ac.)	Forest Edge (ac.) (calculated at 50' width)	NNI Priority	Reforestation	Afforestation (ac.)	Deer Exclosures	Trash
Dickeyville-Purnell	Stand A	23.0	18.9	III	8.82	1.62		
Gwynns Falls Floodplain	Stand B	40.3	36.3	III	18.92			
Gwynns Falls Floodplain	Stand C	24.6	20.6	III	13.50	4.38		
Dead Run Floodplain	Stand D	44.4	39.3	III	14.93			
Dickeyville-Purnell	Stand E	11.1	1.6	I				
GFLP NE	Stand F	12.8	0.7	I				
GFLP NE	Stand G	25.8	2.9	II				
GFLP NE	Stand H	25.1	8.5	III	8.78	3.37		
GFLP NE	Stand I	14.7	5.5	III	5.44			
GFLP NE	Stand J	25.2	12.3	III	13.01	3.34		
GFLP NE	Stand K	20.1	7.2	III	9.05			
GFLP NE	Stand L	6.4	3.1	III	5.14			
GFLP NW	Stand M	25.5	2.9	I			X	X
GFLP NW	Stand N	15.5	4.1	II				
GFLP NW	Stand O	17.8	3.6	III	5.87		X	
GFLP NW	Stand P	26.0	10.8	II	13.87	17.44		
GFLP NW	Stand Q	19.6	3.7	II	7.99		X	
GFLP NW	Stand R	45.2	7.0	III	20.85		X	
GFLP NW	Stand S	46.9	4.9	II	9.20		X	
GFLP NW	Stand T	27.7	2.5	I			X	
GFLP NW	Stand U	13.6	0.4	I				X

Table F: Management Activity Summary (cont.)

Management Unit	Stand	Forested Area (ac.)	Forest Edge (ac.) (calculated at 50' width)	NNI Priority	Reforestation	Afforestation (ac.)	Deer Exclosures	Trash
GFLP NW	Stand V	20.5	1.3	II				X
GFLP NW	Stand W	17.3	4.5	III	4.97			
GFLP SW	Stand X	17.6	1.8	I		1.1	X	
GFLP SW	Stand Y	23.7	3.1	I		1.6	X	
GFLP SW	Stand Z	19.1	8.0	I				
GFLP SE	Stand AA	5.4	0.9	I				
GFLP SE	Stand BB	20.9	2.5	I				
GFLP SE	Stand CC	21.2	2.6	I				
GFLP SE	Stand DD	22.1	2.4	II		1.37	X	
GFLP SE	Stand EE	16.3	2.8	III	4.61	2.04		
GFLP SE	Stand FF	54.6	4.5	II		0.65	X	
GFLP SE	Stand GG	46.9	3.5	II	16.42	3.32		X
GFLP SE	Stand HH	22.4	9.9	III	8.40			X
	Totals	**819.2**	**47.8**		**34.4**	**10.1**		

addressed through underplanting and filling canopy gaps with native species. Management objectives for this stand should be to treat invasives and to plant natives. As with the other floodplain stands, it has a high level of NNI presence, and a significant area over 15% slope, which is sensitive to erosion during NNI management (see Table A: Stand Summary).

Stand E

Acres: 11.1
Location: Dickeyville-Purnell Management Unit
Forest Type: Tulip Poplar-Oak
Dominant Canopy Species: tulip poplar, American beech

This stand is relatively free of invasive vegetation except for the forest edges along the south side of Wetheredsville Road and south along the Dicky Hill Forest housing complex. A small amount of English ivy was observed here so early treatment would be critical to preventing a future serious issue. Norway maple is present in the canopy and their removal should be coordinated with native replacement plantings. The stand should be checked annually for invasive vegetation and it should be controlled as needed. No vines were recorded in this stand canopy. 85% of the stand is over 15% slope, making it very sensitive to erosion during NNI management (see Table A: Stand Summary).

Stand F

Acres: 12.8
Location: GFLP NE Management Unit, near Wakefield and West Forest Park neighborhoods
Forest Type: Tulip Poplar-Beech
Dominant Canopy Species: tulip poplar

Stand F is an isolated parcel of GFLP that encompasses a small ravine which extends north from the Gwynns Falls just north of the Windsor Mill Rd crossing. Although surrounded by mature upland oak-hickory forest, most of the stand is comprised of disturbed floodplain forest community with utility right-of-way through the middle. Due to the recent disturbance and presence of active trails, the presence of NNI is relatively high. Management activities in this stand should consist of treatment of NNI and annual monitoring for spread of NNI into adjacent forest areas. Gaps in canopy created by NNI treatment should be reforested and the forest

understory enhanced through native underplanting. A significant area of the stand is over 15% slope, which is sensitive to erosion during NNI management (see Table A: Stand Summary).

Stand G

Acres: 25.8
Location: GFLP NE Management Unit, near Mt. Holly and Fairmont neighborhoods
Forest Type: Tulip Poplar-Oak
Dominant Canopy Species: tulip poplar, white ash

This stand is in a steep area with almost 85% of the site having greater than 15% slopes, making it very sensitive to erosion during NNI management (see Table A: Stand Summary). Although the understory has a low NNI cover, the canopy is partially composed of Norway maple and also contains English ivy. Management activities should focus on treatment of existing NNI and annual monitoring for spread of NNI into this stand.

Stand H

Acres: 25.1
Location: GFLP NE Management Unit, near Mt. Holly and Fairmont neighborhoods
Forest Type: Tulip Poplar
Dominant Canopy Species: tulip poplar

This stand contains active use facilities and trails along with a high percentage of edge and disturbance. These factors have led to a relatively high concentration of NNI species. Management objectives in this stand should focus on clearing the numerous invasives throughout the stand understory and canopy. A significant area of this stand is over 15% slope, which is sensitive to erosion during NNI management (see Table A: Stand Summary). Open space along the edges of playing fields provides over 3 acres of possible afforestation area. Afforestation and reforestation plantings should occur in conjunction with invasives control adjacent to plantings. The majority of the seedlings present in this stand are ash, therefore it is recommended that the City plant a variety of other native species to increase the diversity of natural regeneration.

Stand I

Acres: 14.7

Location: GFLP NE Management Unit, near Mt. Holly and Fairmont neighborhoods

Forest Type: Oak Northern Hardwoods

Dominant Canopy Species: white oak, American beech

This stand has steep slopes over 15% on almost 85% of the site area, making it very sensitive to erosion during NNI management (see Table A: Stand Summary). Steep slopes combined with the almost 50 invasive trees/acre in the overstory calls for heightened measures to prevent soil loss from erosion during removal of established vegetation and subsequent forest restoration.

Stand J

Acres: 25.2

Location: GFLP NE Management Unit, near Mt. Holly and Fairmont neighborhoods

Forest Type: Mixed Hardwoods

Dominant Canopy Species: white ash, red oak, white oak

Similar to stand H, this stand contains active use facilities and trails along with a high percentage of edge and disturbance with associated high concentrations of NNI. Management objectives in this stand should focus on clearing the numerous invasives in the understory and canopy. A significant area of this stand is over 15% slope, which is sensitive to erosion during NNI management (see Table A: Stand Summary). Open space along the edges of playing fields provides over 3 acres of possible afforestation area. Afforestation and reforestation plantings should occur in conjunction with invasives control adjacent to plantings. Most of the seedlings present in this stand are ash as well, and planting a diverse suite of natives to supplement natural regeneration is recommended.

Stand K

Acres: 20.1

Location: GFLP NE Management Unit, near Mt. Holly and Fairmont neighborhoods

Forest Type: Mixed Hardwoods

Dominant Canopy Species: American beech, red maple, tulip poplar

Management objectives in this stand should focus on clearing the numerous invasives throughout the stand understory and canopy. Just over half the area of this stand has greater than 15% slope, which is sensitive to erosion during NNI management (see Table A: Stand Summary). Afforestation and reforestation plantings should occur in conjunction with invasives control adjacent to plantings. This stand has a large number of trees with vines in the canopy that need treatment.

Stand L

Acres: 6.4
Location: GFLP NE Management Unit, near Mt. Holly and Fairmont neighborhoods
Forest Type: Mixed Hardwoods
Dominant Canopy Species: white ash, boxelder

This stand contains a high percentage of edge and disturbance. Management objectives in this stand should focus on clearing the numerous invasives throughout the stand understory and canopy. Two-thirds of this stand has greater than 15% slopes, making it very sensitive to erosion during NNI management (see Table A: Stand Summary). Afforestation and reforestation plantings should occur in conjunction with invasives control adjacent to plantings. This stand has a large number of trees with vines in the canopy that need treatment.

Stand M

Acres: 25.5
Location: GFLP NW Management Unit, near Wakefield and West Forest Park neighborhoods
Forest Type: Tulip Poplar
Dominant Canopy Species: tulip poplar

This stand has a fairly gentle slope on two-thirds of its area, and greater than 15% slope on the other third, which is sensitive to erosion during NNI management (see Table A: Stand Summary). Much of the steep topography occurs at the northern end of the stand in the form of unique rock outcrops. Management activities should focus on treatment of the existing minimal amount of NNI and annual monitoring for spread of NNI into this stand. This stand is predominantly tulip poplar, so planting a variety of seedlings with deer protection is recommended to assist in increasing diversity in the future canopy. The western half of the stand contains a significant amount of trash from illegal dumping.

Stand N

Acres: 15.5
Location: GFLP NW Management Unit, near Wakefield and West Forest Park neighborhoods
Forest Type: Tulip Poplar-Beech
Dominant Canopy Species: tulip poplar, American beech

Management objectives should focus on clearing the relatively low percentage of NNI in the stand understory and canopy. Almost two-thirds of this stand has greater than 15% slope, which is sensitive to erosion during NNI management (see Table A: Stand Summary). Afforestation and reforestation plantings should occur in conjunction with invasives control adjacent to plantings.

Stand O

Acres: 17.8
Location: GFLP NW Management Unit, near Franklintown neighborhood
Forest Type: Mixed Hardwoods
Dominant Canopy Species: tulip poplar, tree of heaven, Norway maple

This area has been heavily impacted in the past from human activity and contains a large amount of invasive vegetation. Reforestation plantings are recommended in conjunction with invasives control. Almost 50% of the stand has a slope greater than 15%, which is sensitive to erosion during NNI management (see Table A: Stand Summary). Much of that steep area is concentrated in the southeast quadrant.

Stand P

Acres: 26.0
Location: GFLP NW Management Unit, near Franklintown neighborhood
Forest Type: Tulip Poplar-Oak
Dominant Canopy Species: tulip poplar, white oak, white ash

This area has been heavily impacted in the past from human activity and contains a large amount of open grass, active recreation facilities, and invasive vegetation in hedgerows/ edges. Open space along the edges of playing fields provides over 17 acres of possible afforestation area. Afforestation plantings should occur in conjunction with invasives control adjacent to

plantings. This stand has a large number of trees with vines in the canopy that need treatment. With just under 10% of the stand having a slope greater than 15%, this stand has a relatively low level of sensitivity to erosion from NNI management (see Table A: Stand Summary).

Stand Q

Acres: 19.6
Location: GFLP NW Management Unit, near Franklintown neighborhood
Forest Type: Mixed Hardwoods
Dominant Canopy Species: tulip poplar, white ash, black walnut

Management objectives in this stand should focus on clearing the numerous invasives throughout the stand understory and canopy. With just under 15% of this area having a slope greater than 15%, this stand has a relatively low level of sensitivity to erosion from NNI management (see Table A: Stand Summary). Future construction of a natural gas transmission line will bisect this stand and provide an additional pathway for NNI invasion. Removal of invasives will provide plenty of space to underplant with native species. The gas line ROW should be maintained in a native meadow community to provide habitat and help prevent the spread of NNI species.

Stand R

Acres: 45.2
Location: GFLP NW Management Unit, near Franklintown neighborhood
Forest Type: Tulip Poplar Bottomland Hardwoods
Dominant Canopy Species: tulip poplar, green ash

This sensitive stand contains a stream and associated wetlands within its core. It has been heavily impacted in the past from human activity. The stand contains the Carrie Murray Nature center facilities and trails, as well as a large amount of invasive vegetation. Reforestation plantings should occur in conjunction with invasives control. About 40% of the site has a slope steeper than 15%, which is sensitive to erosion during NNI management (see Table A: Stand Summary). These steeper areas occur throughout the stand. Although a natural gas transmission line is proposed to bisect this stand, the route will follow an existing roadway and should be managed to not increase the amount of forest edge.

Stand S

Acres: 46.9

Location: GFLP NW Management Unit, near Franklintown neighborhood

Forest Type: Tulip Poplar-Beech

Dominant Canopy Species: tulip poplar, American beech

Approximately 70% of this stand has a slope greater than 15%, which is sensitive to erosion during NNI management (see Table A: Stand Summary). Much of that steeper area is concentrated in the south and east portions of the stand. This stand contains a relatively low percentage of NNI species, but potential exists for the spread of Japanese honeysuckle, common periwinkle, oriental bittersweet, multiflora rose, Japanese stiltgrass, English ivy, Japanese barberry, and garlic mustard observed there. Management activities should focus on treatment of existing NNI and annual monitoring for spread of NNI into this stand. Additionally, oak regeneration/restoration is recommended, with deer protection for the seedlings.

Stand T

Acres: 27.7

Location: GFLP NW Management Unit, near Franklintown neighborhood

Forest Type: Tulip Poplar-Oak

Dominant Canopy Species: tulip poplar, white oak

Half of this stand has a slope greater than 15%, which is sensitive to erosion during NNI management (see Table A: Stand Summary). Most of that area is concentrated in the south and east portions of the stand. This stand contains a relatively low percentage of NNI species but there is potential for spread of existing oriental bittersweet, Japanese honeysuckle, English ivy, common periwinkle, and Norway maple. Management activities should focus on treatment of existing NNI and annual monitoring for spread of NNI into this stand. Although a natural gas transmission line is proposed to cross through this stand, the route will follow the western edge of the stand and should not increase the amount of forest edge. Due to restrictions in vegetation cover in this right-of-way, vegetation stabilization is limited to herbaceous plants and a native meadow community is recommended.

Stand U

Acres: 13.6

Location: GFLP NW Management Unit, near Franklintown neighborhood

Forest Type: Mixed Hardwoods

Dominant Canopy Species: American elm, tulip poplar

This sensitive stand contains a stream and associated wetlands within its core. It has been impacted in the past from human activity and contains a high ropes course facility and trails with a moderate amount of invasive vegetation. An area of trash dumping is present along the east side of this stand. Reforestation plantings should occur in conjunction with invasives control. About 60% of the site has slopes steeper than 15%, with much of that area flanking both the east and west sides of the stand. These steeper areas are sensitive to erosion during NNI management (see Table A: Stand Summary).

Stand V

Acres: 20.5

Location: GFLP NW Management Unit, near Franklintown neighborhood

Forest Type: Tulip Poplar-Oak

Dominant Canopy Species: tulip poplar, American beech, white ash

Over two-thirds of this stand has a slope greater than 15%, making this stand very sensitive to erosion during NNI management (see Table A: Stand Summary). The stand has a relatively small invasive species percent cover. Management activities in this priority area should focus on treatment of existing vines and annual monitoring for spread of invasives into this stand. An area of trash dumping is present along the west side of this stand. Reforestation plantings should occur in conjunction with invasives control. Additionally, planted and volunteer oak or hickory seedlings in this stand should be protected from deer to assist in establishing regeneration of the existing oak forest.

Stand W

Acres: 17.3

Location: GFLP NW Management Unit, near Franklintown neighborhood

Forest Type: Mixed Hardwoods

Dominant Canopy Species: white oak, tulip poplar

A significant amount of NNI species are present in all strata of this stand. Additionally, two-thirds of the area has a slope over 15% (see Table A: Stand Summary). The prevalence of invasive species and steep slopes makes this stand very sensitive to erosion from NNI management. Management activities in this priority area should focus on treatment of invasives and the protection of existing desirable tree seedlings from deer to assist in establishing regeneration of the canopy.

Stand X

Acres: 17.6
Location: GFLP SW Management Unit, near West Hills and Hunting Ridge neighborhoods
Forest Type: Tulip Poplar-Beech
Dominant Canopy Species: tulip poplar, American beech, white oak

Management objectives in this stand should include afforestation of the clearing at the terminus of Interstate 70. The invasives throughout the stand understory and along the forest edge should be treated to further enhance the good condition of the forest. Over 40% of the site has a slope of 15% or greater, which is sensitive to erosion during NNI management (see Table A: Stand Summary). Protection of the numerous existing desirable native seedlings from deer should occur in this stand to assist in establishing regeneration of the oak canopy. No vines were recorded in this stand canopy.

Stand Y

Acres: 23.7
Location: GFLP SW Management Unit, near West Hills and Hunting Ridge neighborhoods
Forest Type: Oak Northern Hardwoods
Dominant Canopy Species: black oak, white oak, tulip poplar

While almost 60% of this stand has a slope greater than 15%, which is sensitive to erosion during NNI management (see Table A: Stand Summary), the only invasives recorded in this area were vines in the canopy. Management activities in this priority area should focus on treatment of existing vines and annual monitoring for spread of invasives into this stand. Additionally, protection of the numerous existing desirable seedlings from deer should occur in this stand to assist in regenerating a desirable canopy.

Stand Z

Acres: 19.1

Location: GFLP SW Management Unit, near West Hills and Hunting Ridge neighborhoods

Forest Type: Tulip Poplar-Beech

Dominant Canopy Species: tulip Poplar, American beech, white oak

Almost 60% of this stand has a slope greater than 15% (see Table A: Stand Summary), and a moderate amount of invasives are recorded as ground cover. This combination makes the stand very sensitive to erosion from NNI management. Activities in this priority area should focus on treatment of existing NNI and annual monitoring for spread of invasives into this stand. Additionally, protection of existing desirable seedlings from deer should be considered in this stand to assist in establishing regeneration.

Stand AA

Acres: 5.4

Location: GFLP SE Management Unit, near Rognell Heights neighborhood

Forest Type: Tulip Poplar-Oak

Dominant Canopy Species: tulip poplar, black oak, white oak

This stand contains one of the few groups of chestnut oak in GFLP. This stand is considered priority for NNI management due to the low percentage of invasive species. There is potential for spread of the existing oriental bittersweet, Japanese stiltgrass, English ivy, and garlic mustard. Management activities should focus on treatment of existing NNI and annual monitoring for spread of NNI into this stand. With 89% of the stand area having slopes greater than 15%, this stand has the greatest percentage of area that is sensitive to erosion from NNI management. Additionally, protection of numerous desirable native seedlings from deer should be considered in this stand to assist in establishing regeneration of the oak canopy. No vines were recorded in this stand canopy.

Stand BB

Acres: 20.9

Location: GFLP SE Management Unit, near Rognell Heights neighborhood

Forest Type: Oak Northern Hardwoods

Dominant Canopy Species: black oak, American beech, tulip poplar

This stand borders a stream along its entire eastern boundary. Similar to Stand AA, this stand contains large mixed oaks and is considered a protection priority due to the low percentage of NNI but the potential for spread of the existing vines. Management activities should focus on treatment of existing NNI and annual monitoring for spread of NNI into this stand. 86% of the site has a slope of 15% or greater, making the stand very sensitive to erosion from NNI management. Additionally, protection of existing native seedlings from deer should be considered in this stand to assist in establishing regeneration of the oak canopy.

Stand CC

Acres: 21.2
Location: GFLP SE Management Unit, near Rognell Heights neighborhood
Forest Type: Tulip Poplar-Oak
Dominant Canopy Species: black oak, chestnut oak

Similar to Stand AA, this stand contains one of the few other groups of chestnut oak in GFLP. Also like stand AA, nearly 90% of the stand has a slope greater than 15% (see Table A: Stand Summary), making this area very sensitive to NNI management-caused erosion. This stand is considered a protection priority due to the low percentage of NNI but the potential for spread of the existing oriental bittersweet, English ivy, and bush honeysuckle. Management activities should focus on treatment of existing NNI and annual monitoring for spread of NNI into this stand. Additionally, protection of existing native seedlings from deer should be considered in this stand to assist in establishing regeneration of the oak canopy. This stand also contains an existing natural gas transmission line and is proposed to have another installed through the steepest slope area. Stabilization through revegetation is essential in these areas and should be maintained in dry meadow community. No vines were recorded in this stand canopy.

Stand DD

Acres: 22.1
Location: GFLP SE Management Unit, near Rognell Heights neighborhood
Forest Type: Tulip Poplar-Oak
Dominant Canopy Species: tulip poplar

This stand has been impacted in the past from human activity and contains a large amount of invasive vegetation surrounding an active use recreation area. Open space along the stands

southern edge provides approximately 1.3 acres of possible afforestation area. Reforestation plantings are recommended in conjunction with invasives control. A significant area of this stand has a slope of 15% or greater, which is sensitive to erosion during NNI management (see Table A: Stand Summary). No vines were recorded in this stand canopy.

Stand EE

Acres: 16.3
Location: GFLP SE Management Unit, near Rognell Heights neighborhood
Forest Type: Mixed Hardwoods
Dominant Canopy Species: American beech, green ash

This sensitive stand contains a stream and associated wetlands within the core of its area. The stand has a high percentage of vines in the canopy and contains kudzu along the southern forest edge, which should be considered a priority species for treatment. 60% of this stand has a slope of 15% or greater, which is sensitive to erosion during NNI management (see Table A: Stand Summary). Also along the southern edge of the stand, there are approximately 2 acres of potential afforestation.

Stand FF

Acres: 54.6
Location: GFLP SE Management Unit, near Edmondson Village neighborhood
Forest Type: Tulip Poplar-Oak
Dominant Canopy Species: tulip poplar, white oak, green ash

This hydrologically sensitive stand contains multiple short streams draining to its northern boundary and 75% of the site contain slopes of 15% or greater (see Table A: Stand Summary). This combination also makes the stand very sensitive to erosion during NNI management. Possible opportunities for 0.65 acres of afforestation occur along the site's southwestern boundary with an existing active use park. No vines were recorded in this stand canopy.

Stand GG

Acres: 46.9
Location: GFLP SE Management Unit, near Edmondson Village neighborhood
Forest Type: Mixed Hardwoods
Dominant Canopy Species: tulip poplar, green ash

This stand has been heavily impacted in the past from human activity and contains a large amount of trash (possibly a dump site), invasive vegetation and an existing natural gas transmission line. Open space along the stand' southwestern edge provides over 3 acres of possible afforestation area. Reforestation plantings should occur in conjunction with invasives control. No vines were recorded in this stand canopy. Nearly half of the stand has a slope greater than 15%, which is sensitive to erosion from NNI management (see Table A: Stand Summary).

Stand HH

Acres: 22.4
Location: GFLP SE Management Unit, near Edmondson Village neighborhood
Forest Type: Mixed Hardwoods
Dominant Canopy Species: green ash, white oak

This stand contains a stream through its interior with 65% of the site containing slopes of 15% or greater (see Table A: Stand Summary). The combination makes this stand very sensitive to erosion from NNI management. The southern half of the stand contains a significant amount of trash in the form of illegal dumping. Included in this stand are the greenspaces between the Hilton Parkway travel lanes and exit clover-leaves which would benefit from both invasives treatment and reforestation with natives. No vines were recorded in this stand canopy.

Future Natural Gas Pipeline

The future condition of several stands will be impacted by a proposed natural gas pipeline to be installed through GFLP. Based on the 9/16/16 limit of disturbance for the proposed gas line, the utility will add approximately 1.7 miles of new edge, directly impacting Stands B, D, P, Q, R, S, T, U, X, CC, FF, and GG (see Figure E: Forest Edge). The installation of the gas line will remove existing forest which cannot be replaced in situ because of requirements of the pipeline easement. These new openings in the existing forest have the potential to act as vectors for

introduction of NNI into areas not currently invaded or with limited NNI already present. These sites should be re-vegetated with a mix of appropriate native herbaceous species. Regular monitoring for NNI introductions should occur on an annual basis during the middle of the growing season. Visual inspection of these corridors and the immediately adjacent forest community will reduce the potential for introduction and spread of undesirable vegetation.

6 BUDGET RECOMMENDATIONS

It is assumed that current forest management budgets within the City are limited to reforestation efforts that are incidental to other infrastructure projects. These efforts tend to be limited in scope and duration as they relate to maintenance of tree and forest health. Funding for the ongoing maintenance and management of GFLP trees and forest is the responsibility of the City of Baltimore. Further development of specific anticipated budgets for the targeted stands is displayed in Table H: Stand Management Prioritization & Estimated Costs to assist the City in estimating needs. It is difficult to put a static cost on a project involving biological systems due to several inter-related variables. Weather, difficult topography, access, change in plant density, presence of endangered/ sensitive species, change in browse intensity, citizen concerns, vandalism, variable fuel and materials cost, and other factors affect pricing.

NNI Vegetation Management Estimates

Budgetary estimates and recommendations are based upon a quantitative inventory of vegetation communities, infrastructure conditions, and maintenance requirements. A professional opinion for the current extent and severity of the invasive vegetation occurrences on the study parcels has been developed. This estimate is grounded in the quantitative assessment of field conditions that was performed during the course of this project. While the total park area is approximately 1,200 acres, existing GIS files indicate that approximately 800 acres are forested. The majority of that 800 acres of forest is occupied by some amount of NNI species. The invasive recommendations have thus been based upon a potential treatment area of approximately 800 acres to varying degrees.

The analysis resulted in a range of values for the expected variability of invasive infestation levels. A high, medium, and low ranking of potential NNI cover values was created (see Table G: Estimated Productivity of Invasive Treatment Field Crews by NNI Cover Level). This information was used to produce three potential treatment effort (acre/day) scenarios based on the NNI cover ranking for each stand. Realistic contract crew day treatment costs were then integrated into each scenario based upon professional experience on the labor inputs that are required to address the various cover values of invasives in each scenario. The intent of this computation was to produce an estimate of the resource allocation that would be required to address the entire invasive suppression effort in the GFLP management area over a period of ten years.

Table G: Estimated Productivity of Invasive Treatment Field Crews by NNI Cover Level

Invasive Cover Level	Four-Person Crew Productivity
0-5% (low)	5 acres per day
5-25% (medium)	1 acre per day
>25% (high)	0.5 acre per day

Based on current (2017) vegetation management industry quotes, NNI treatment budgets utilize the assumption of a crew day cost of $2150 for an area of moderate NNI cover, which includes: a 4-person crew (1 foreman, 3 laborers) working for 10 hours (2 travel, 8 labor), and $250 in herbicide.

Level of treatment effort for a stand (1=least to 3=most) is determined using percent cover estimates and/or stem count estimates for NNI species within each of the three vegetative strata (0-3', 3-10', >10'). The level of effort for the crew increases with a higher NNI cover percentage and/or stem count, while daily productivity decreases. As productivity decreases, the per-acre cost increases, because it takes longer for that crew of four to treat an acre. Per-acre costs for each of the three effort levels are: 1=$450/acre, 2=$2150/acre, 3=$4300/acre.

Acreage calculations for each stand, for 0-3' and 3-10' forest strata, are separated into forest edge and forest interior, and per-acre costs applied to each based on the assigned level of effort. For the purposes of NNI treatment, forest edges comprise forested area that is 50' from roads, former roads now used as trails, large lawn areas, and active use facilities. Forested area that does not meet this definition of a forest edge, is calculated as forest interior for the purposes of NNI treatment. Forest edge in each stand is calculated separately and assigned a one level increase in effort level (except for stands where the forest interior also a level 3 effort), because edge areas were observed to have greater NNI density. If the forest interior has an effort level of 3 (the highest effort level), the forest edge effort level is also assigned an effort level of 3.

It is assumed that the initial treatment will result in a 75% reduction in NNI cover and therefore year 2 treatment costs will be 25% of year 1. Year 3 treatment costs are assumed to be 10% of year 1, and year 4 treatment costs drop to only 5% of the initial treatment. Subsequent treatments from this point forward should be reduced to spot treating and monitoring, with annual costs stabilized at a minimum required to cover the stand for visual assessment. Annual

Table H: Stand Management Prioritization and Estimated Costs

Note: Annual costs are per stand and it is NOT expected that all stands are managed every year.

Priority Level	Management Unit	Stand	Acres	Estimated Cost- NNI: TREATMENT YEAR 1	TREATMENT YEAR 2	TREATMENT YEARS 3 -10	Total	Estimated Cost- REFORESTATION: PLANTING YEAR 1	PLANTING YEAR 2	PLANTING YEARS 3 -10	Total
I	GFLP SE	CC	21	$ 15,200.00	$ 3,800.00	$ 17,200.00	$ 36,200.00	**$ -**	**$ -**	**$ -**	$ -
	GFLP NE	F	13	$ 52,000.00	$ 13,000.00	$ 16,700.00	$ 81,700.00	$ -	$ -	$ -	$ -
	Dickeyville-Purnell	E	11	$ 14,900.00	$ 3,700.00	$ 9,900.00	$ 28,500.00	$ -	$ -	$ -	$ -
	GFLP SE	AA	5	$ 14,000.00	$ 3,500.00	$ 5,900.00	$ 23,400.00	$ -	$ -	$ -	$ -
	GFLP NW	U	14	$ 35,000.00	$ 8,800.00	$ 14,800.00	$ 58,600.00	$ 230,200.00	$ 15,300.00	$ 32,100.00	$ 277,600.00
	GFLP SW	X	18	$ 44,700.00	$ 11,200.00	$ 19,100.00	$ 75,000.00	$ -	$ -	$ -	$ -
	GFLP SW	Z	19	$ 68,300.00	$ 17,100.00	$ 23,500.00	$ 108,900.00	$ -	$ -	$ -	$ -
	GFLP NW	M	25	$ 45,700.00	$ 11,400.00	$ 24,700.00	$ 81,800.00	$ 210,300.00	$ 14,000.00	$ 29,200.00	$ 253,500.00
	GFLP NW	T	28	$ 79,000.00	$ 19,800.00	$ 31,200.00	$ 130,000.00	$ 224,500.00	$ 15,000.00	$ 31,500.00	$ 271,000.00
	GFLP SW	Y	24	$ 67,600.00	$ 16,900.00	$ 26,600.00	$ 111,100.00	$ -	$ -	$ -	$ -
	GFLP SE	BB	21	$ 64,300.00	$ 16,100.00	$ 24,100.00	$ 104,500.00	$ -	$ -	$ -	$ -
		Sub-total	**198**	**$ 500,700.00**	**$ 125,300.00**	**$ 213,700.00**	**$ 839,700.00**	**$ 665,000.00**	**$ 44,300.00**	**$ 92,800.00**	**$ 802,100.00**
II	GFLP SE	N	16	$ 69,000.00	$ 17,300.00	$ 21,200.00	$ 107,500.00	$ 87,300.00	$ 5,800.00	$ 12,200.00	$ 105,300.00
	GFLP NW	S	47	$ 196,700.00	$ 49,200.00	$ 62,100.00	$ 308,000.00	$ 292,300.00	$ 19,500.00	$ 40,800.00	$ 352,600.00
	GFLP NW	V	21	$ 88,400.00	$ 22,100.00	$ 27,500.00	$ 138,000.00	$ 154,000.00	$ 10,300.00	$ 21,500.00	$ 185,800.00
	GFLP NW	DD	22	$ 107,300.00	$ 26,800.00	$ 31,400.00	$ 165,500.00	$ 198,800.00	$ 13,300.00	$ 27,800.00	$ 239,900.00
	GFLP SE	G	26	$ 110,400.00	$ 27,600.00	$ 34,500.00	$ 172,500.00	$ 347,800.00	$ 23,200.00	$ 48,500.00	$ 419,500.00
	GFLP NE	P	26	$ 242,300.00	$ 60,600.00	$ 54,400.00	$ 357,300.00	$ 390,000.00	$ 26,000.00	$ 54,400.00	$ 470,400.00
	GFLP NW	Q	20	$ 136,800.00	$ 34,200.00	$ 34,200.00	$ 205,200.00	$ 176,100.00	$ 11,700.00	$ 24,600.00	$ 212,400.00
	GFLP NW	FF	55	$ 389,600.00	$ 97,400.00	$ 96,500.00	$ 583,500.00	$ 321,400.00	$ 21,400.00	$ 44,700.00	$ 387,500.00
	GFLP SE	GG	47	$ 340,300.00	$ 85,100.00	$ 83,600.00	$ 509,000.00	$ 652,400.00	$ 43,500.00	$ 90,900.00	$ 786,800.00
		Sub-total	**278**	**$ 1,680,800.00**	**$ 420,300.00**	**$ 445,400.00**	**$ 2,546,500.00**	**$ 2,620,100.00**	**$ 174,700.00**	**$ 365,400.00**	**$ 3,160,200.00**
III	GFLP SE	C	25	$ 332,400.00	$ 83,100.00	$ 66,900.00	$ 482,400.00	$ 331,400.00	$ 22,100.00	$ 46,300.00	$ 399,800.00
	Gwynns Falls Floodplain	D	44	$ 547,900.00	$ 137,000.00	$ 113,100.00	$ 798,000.00	$ 218,000.00	$ 14,500.00	$ 30,200.00	$ 262,700.00
	Gwynns Falls Floodplain	H	25	$ 210,900.00	$ 52,700.00	$ 49,100.00	$ 312,700.00	$ 451,400.00	$ 30,100.00	$ 62,900.00	$ 544,400.00
	GFLP NE	I	15	$ 129,800.00	$ 32,500.00	$ 29,700.00	$ 192,000.00	$ 119,000.00	$ 7,900.00	$ 16,400.00	$ 143,300.00
	GFLP NE	J	25	$ 232,200.00	$ 58,100.00	$ 52,400.00	$ 342,700.00	$ 226,600.00	$ 15,100.00	$ 31,700.00	$ 273,400.00
	GFLP NE	L	6	$ 64,600.00	$ 16,200.00	$ 14,200.00	$ 95,000.00	$ 115,700.00	$ 7,700.00	$ 16,000.00	$ 139,400.00
	GFLP NE	W	17	$ 121,500.00	$ 30,400.00	$ 30,300.00	$ 182,200.00	$ 252,600.00	$ 16,800.00	$ 35,100.00	$ 304,500.00
	GFLP NW	EE	16	$ 124,200.00	$ 31,100.00	$ 30,000.00	$ 185,300.00	$ 195,400.00	$ 13,000.00	$ 27,200.00	$ 235,600.00
	GFLP SE	HH	22	$ 227,800.00	$ 57,000.00	$ 49,900.00	$ 334,700.00	$ 151,100.00	$ 10,100.00	$ 21,100.00	$ 182,300.00
	GFLP SE	K	20	$ 197,000.00	$ 49,300.00	$ 43,600.00	$ 289,900.00	$ 294,100.00	$ 19,600.00	$ 41,000.00	$ 354,700.00
	GFLP NE	R	45	$ 392,600.00	$ 98,200.00	$ 90,300.00	$ 581,100.00	$ 594,100.00	$ 39,600.00	$ 82,800.00	$ 716,500.00
	GFLP NW	B	40	$ 650,700.00	$ 162,700.00	$ 125,700.00	$ 939,100.00	$ 489,200.00	$ 32,600.00	$ 68,200.00	$ 590,000.00
	Gwynns Falls Floodplain	O	18	$ 244,000.00	$ 61,000.00	$ 49,000.00	$ 354,000.00	$ 112,000.00	$ 7,500.00	$ 15,600.00	$ 135,100.00
	GFLP NW	A	23	$ 511,500.00	$ 127,900.00	$ 92,700.00	$ 732,100.00	$ 345,000.00	$ 23,000.00	$ 48,100.00	$ 416,100.00
		Sub-total	**343**	**$ 3,987,100.00**	**$ 997,200.00**	**$ 836,900.00**	**$ 5,821,200.00**	**$ 3,895,600.00**	**$ 259,600.00**	**$ 542,600.00**	**$ 4,697,800.00**
		Total	**819**	**$ 6,168,600.00**	**$ 1,542,800.00**	**$ 1,496,000.00**	**$ 9,207,400.00**	**$ 5,154,700.00**	**$ 343,500.00**	**$ 718,200.00**	**$ 6,216,400.00**

			Estimated Cost- AFFORESTATION: Area (Acres)	YEAR 1	YEAR 2	YEARS 3 -10	Total	Estimated Cost- DEER EXCLOSURES: Area (Acres)	YEAR 1	YEAR 2	YEARS 3 -10	Total
1	Dickeyville-Purnell	A	1.62	$ 43,700.00	$ 3,200.00	$ 9,100.00	$ 56,000.00		**$ -**	**$ -**	**$ -**	$ -
2	Gwynns Falls Floodplain	B					$ -		$ -	$ -	$ -	$ -
3	Gwynns Falls Floodplain	C	4.38	$ 118,300.00	$ 8,800.00	$ 25,000.00	$ 152,100.00		$ -	$ -	$ -	$ -
4	Gwynns Falls Floodplain	D					$ -		$ -	$ -	$ -	$ -
5	Dickeyville-Purnell	E					$ -		$ -	$ -	$ -	$ -
6	GFLP NE	F					$ -					$ -
7	GFLP NE	G					$ -		$ -	$ -	$ -	$ -
8	GFLP NE	H	3.37	$ 91,000.00	$ 6,700.00	$ 19,100.00	$ 116,800.00		$ -	$ -	$ -	$ -
9	GFLP NE	I					$ -		$ -	$ -	$ -	$ -
10	GFLP NE	J	3.34	$ 90,200.00	$ 6,700.00	$ 19,000.00	$ 115,900.00		$ -	$ -	$ -	$ -
11	GFLP NE	K					$ -		$ -	$ -	$ -	$ -
12	GFLP NE	L					$ -		**$ -**	**$ -**	**$ -**	$ -
13	GFLP NW	M					$ -	7	$ 18,900.00	$ 3,200.00	$ 39,400.00	$ 61,500.00
14	GFLP NW	N					$ -		$ -	$ -	$ -	$ -
15	GFLP NW	O					$ -	9	$ 24,300.00	$ 3,200.00	$ 43,400.00	$ 70,900.00
16	GFLP NW	P	17.44	$ 470,900.00	$ 34,900.00	$ 99,100.00	$ 604,900.00		$ -	$ -	$ -	$ -
17	GFLP NW	Q					$ -	2	$ 5,400.00	$ 3,200.00	$ 29,300.00	$ 37,900.00
18	GFLP NW	R					$ -	5	$ 36,500.00	$ 3,200.00	$ 52,600.00	$ 92,300.00
19	GFLP NW	S					$ -	5	$ 52,200.00	$ 3,200.00	$ 64,400.00	$ 119,800.00
20	GFLP NW	T					$ -	3	$ 7,500.00	$ 3,200.00	$ 30,800.00	$ 41,500.00
21	GFLP NW	U					$ -		$ -	$ -	$ -	$ -
22	GFLP NW	V					$ -		$ -	$ -	$ -	$ -
23	GFLP NW	W					$ -		$ -	$ -	$ -	$ -
24	GFLP SW	X	1.1	$ 29,700.00	$ 2,200.00	$ 6,200.00	$ 38,100.00	2	$ 4,800.00	$ 3,200.00	$ 28,800.00	$ 36,800.00
25	GFLP SW	Y	1.6	$ 43,200.00	$ 3,200.00	$ 9,100.00	$ 55,500.00	3	$ 8,100.00	$ 3,200.00	$ 31,300.00	$ 42,600.00
26	GFLP SW	Z					$ -		$ -	$ -	$ -	$ -
27	GFLP SE	AA					$ -		$ -	$ -	$ -	$ -
28	GFLP SE	BB					$ -		$ -	$ -	$ -	$ -
29	GFLP SE	CC					$ -		$ -	$ -	$ -	$ -
30	GFLP SE	DD	1.37	$ 37,000.00	$ 2,700.00	$ 7,700.00	$ 47,400.00	3	$ 8,100.00	$ 3,200.00	$ 31,300.00	$ 42,600.00
31	GFLP SE	EE	2.04	$ 55,100.00	$ 4,100.00	$ 11,600.00	$ 70,800.00		$ -	$ -	$ -	$ -
32	GFLP SE	FF	0.65	$ 17,600.00	$ 1,300.00	$ 3,700.00	$ 22,600.00	6	$ 16,200.00	$ 3,200.00	$ 37,400.00	$ 56,800.00
33	GFLP SE	GG	3.32	$ 89,600.00	$ 6,600.00	$ 18,800.00	$ 115,000.00		$ -	$ -	$ -	$ -
34	GFLP SE	HH					$ -		$ -	$ -	$ -	$ -
							$ -					$ -
				$ 1,086,300.00	**$ 80,400.00**	**$ 228,400.00**	**$ 1,395,100.00**		**$ 182,000.00**	**$ 32,000.00**	**$ 388,700.00**	**$ 602,700.00**

increases of 3% for inflation were applied to years 5-10. Total costs were rounded to the nearest $100.

Example NNI Vegetation Management Calculations

Stand T is 27.7 acres of total forest, with 25.2 acres considered to be forest interior and 2.5 acres considered to be forest edge. This stand has NNI present in two layers of vegetation strata: ground (<3') and canopy (>10'). The <3' ground layer contains 5% NNI cover in the form of vines and 40 seedlings/acre of Norway maple. With 5-25% NNI cover, the forest interior of Stand T is assigned an effort level of 2 for this stratum.

25.2 acres of forest interior x $2150/acre (for a level 2 treatment effort) = $54,141.

The forest edge acres of Stand T are assigned an effort level of 3, a one level increase from the effort level for the forest interior.

2.5 acres of edge x $4300/acre (for a level 3 treatment effort)= $10,870.

Added together, treatment costs for the <3' stratum of Stand T are $65,011 for the initial year of treatment.

$54,141 forest interior NNI treatment + $10,870 forest edge NNI treatment= $65,011 for the <3' stratum NNI treatment

Although the 3'-10' forest stratum contained no NNI species in the data collection plots, the forest edge acreage was assigned a level of effort of 1 to cover potential NNI that were present but not recorded during data collection for an additional cost of $1,200.

2.5 acres of edge x $450/acre (for a level 1 treatment effort)= $1,200

The canopy layer of Stand T contains 16 trees per acre that are either NNI species and/or contain NNI vines and require treatment. It was estimated that a crew could treat an acre in just over an hour at that density (8 acre/day, Effort Level 1) and therefore complete the stand in 6 crew days.

27.7 acres x $450/acre (for a level 1 treatment effort)=$12.400 for canopy NNI treatment

Combined with ground stratum treatment costs, the total year 1 NNI treatment costs for Stand T would be $79,000.

$65,011 (<3' stratum) + $1,200 (3'-10' stratum) + $12,900 (>10' stratum)= $79,000

A rough estimate of the cost of maintaining an in-house crew member with the proper equipment to perform maintenance treatments of NNI vegetation would be approximately $90,000 per year. As it is anticipated that most of the areas these individuals will be working on will have been pre-treated by professional contractors, the cover levels of invasive plants should be low. This will increase the daily per acre productivity of crews for maintenance treatments. As

a point of comparison, the anticipated average productivity of four-person invasive field crews using backpack foliar techniques would typically fall within the ranges shown in Table G.

It is anticipated that a large proportion of the treated acreage will eventually require no active treatment for extended periods of time as native plant communities and limitations on site disturbance reduce new infestations to a minimum.

Planting Budget Estimates

Afforestation efforts are based on assumptions of planting larger plant material (1.5" cal.) in currently open, grassy areas. Planting densities of 400 trees/acre would occur with a suite of overstory and understory species. Although minimal site preparation would be required, regular monitoring and maintenance should occur during the first two growing seasons.

Reforestation plantings are assumed to occur in conjunction with NNI vegetation control efforts, and include planting of trees, shrubs, and herbaceous species. Smaller size trees and shrubs should be planted at a 200 trees/acre density where there is an existing partial canopy. Monitoring and maintenance of these locations should occur at more regular intervals due to the greater potential for NNI vegetation to impact plantings. Planting estimates were established using the residual native sapling density and overall NNI presence.

The reforestation costs given for each stand did not make adjustments for relative density and assumed total removal of NNI in the 3-10' height class. Selective planting is recommended in stands with a relative density of 90% or greater as light limitations may negatively impact survival and growth of shade intolerant tree species.

Other assumptions used in determining planting budgets include:

- 1-year 85% plant survival warranty with a potential one-time replacement
- 0.75-1" caliper containerized planting stock
- 3-4' ht containerized shrub planting stock
- Seeding of native herbaceous grasses and forbs at 30-40 lbs. seed/ acre
- 4' bark protectors on trees (for deer rubbing protection)
- 4' tall welded wire mesh cages around shrubs (for deer browse protection)
- mulching

Example Planting Calculations

Stand EE is 16.28 acres of total forest, with 2.8 acres considered to be forest edge and 2.04 acres of non-forested open-space available for planting outside of established playing fields. This forest stand has NNI present and overstory regeneration at 67 saplings/acre of native tree species. With only 33% existing native regeneration after treatment of NNI, the available planting density is approximately 133 stems/acre to achieve the desired 200 stems/acre. Unit costs per stem is approximately $90 each for installation, tree protection and multiple site visits for maintenance of tree protection.

16.28 acres of forest enhancement or reforestation x 133 stems/acre = 2171 stems

2171 stems X $90 = $195,355

The openspace acres of Stand EE are recommended to receive a management action of afforestation to return the area to forested condition. Proposed afforestation plantings include 400 stems/acre of trees and shrubs with mulch and deer protection, seeding of native grasses and forbes and maintenance of plantings and protection for 1 growing season at approximately $27,000/acre.

2.04 acres of afforestation x $27,000/acre = $55,100

Added together, planting costs for the forested and non-forested areas of Stand EE are $250,455 for the initial year of treatment.

$195,355 reforestation planting + $55,100 afforestation planting = $250,455

A 90% survival rate for trees was assumed for calculating the potential replacement costs over the subsequent 4 years within the reforestation area. Replacement unit cost rate is reduced assuming the salvage and reuse of previously installed tree protection. An inflation rate of 2% was added to each year during a 4 year establishment period.

10% of 2171= 217 replacement trees @ $60/tree = $13,000

Maintenance of the afforestation area over the subsequent 4 years was estimated at $2000/acre. An inflation rate of 2% was added to each year during a 4 year establishment period.

2.04 acres of afforestation maintenance x $2,000/acre = $4,100

Soil Management Budgeting

Costs associated with spreading of woody material on-site were estimated based on the assumptions that materials would be included in the price. However, if sourced either from within each stand or from the City's wood waste storage facility, cost could be substantially less. It is also assumed that areas to receive mulch are generally within close proximity (within 300') to a road or trail, and that blown-in fine hardwood mulch prices are $35/per yard.

Deer Exclosure Budget Estimates

Costs associated with deer exclosures were estimated based on the details provided in the Rock Creek National Park deer population assessment and associated management plan. Rock Creek Park is similar to GFLP in size, vegetation community assemblage, regional location and proximity to urban land use. The numbers provided are only for large exclosures as individual tree protection and small cluster fencing is included in the planting costs associated with afforestation and reforestation.

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8 MAP REFERENCES

Figure A: Vicinity Map		
Map File Name: A_Vicinity Map.mxd		
Feature	**File Name**	**Source**
GFLP Park Boundary	park_boundary_GFLP.shp	Baltimore City Department of Recreation & Parks
Basemap	World Topographic Map	ESRI et al. (refer Service Layer Sources on map)

Figure B: Existing Conditions		
Map File Name: B_Existing Conditions.mxd		
Feature	**File Name**	**Source**
10 ft. Contours	contour_index_10ft_clip.shp	Baltimore City Department of Recreation & Parks
Multi-use Trails	trail_multiuse_clip_2011.shp	Baltimore City Department of Recreation & Parks
Hiking Trails	trail_hiking_GFLP_2011.shp	Baltimore City Department of Recreation & Parks
Buildings	building_elevation_clip.shp	Baltimore City Department of Recreation & Parks
Streets	street_area_clip.shp	Baltimore City Department of Recreation & Parks
Streams	hydro_cl_clip2.shp	Baltimore City Department of Recreation & Parks
Waterbodies	water_clip.shp	Baltimore City Department of Recreation & Parks
Background Aerial	NAIP_2015.jpg	USDA Farm Service Agency

Figure C: Existing Conditions		
Map File Name: C_Stands_and_Management_Units.mxd		
Feature	**File Name**	**Source**
Streams	hydro_cl_clip2.shp	Baltimore City Department of Recreation & Parks
Management Units	Management Units.shp	Biohabitats
Forest Stands	GFLP_Stands.shp	Biohabitats
Buildings	building_elevation_clip.shp	Baltimore City Department of Recreation & Parks
Property	realprop_2014_0416.shp	Baltimore City Department of Recreation & Parks
Streets	street_area_clip.shp	Baltimore City Department of Recreation & Parks
Waterbodies	water_clip.shp	Baltimore City Department of Recreation & Parks
Background Aerial	NAIP_2015.jpg	USDA Farm Service Agency

Figure D: Forest Types		
Map File Name: D_Forest_Types.mxd		
Feature	**File Name**	**Source**
10 ft. Contours	contour_index_10ft_clip.shp	Baltimore City Department of Recreation & Parks
Forest Stands	GFLP_Stands.shp	Biohabitats
Forest Types	GFLP_Forest Types.shp	Biohabitats
Buildings	building_elevation_clip.shp	Baltimore City Department of Recreation & Parks
Property	realprop_2014_0416.shp	Baltimore City Department of Recreation & Parks
Streets	street_area_clip.shp	Baltimore City Department of Recreation & Parks
Streams	hydro_cl_clip2.shp	Baltimore City Department of Recreation & Parks
Waterbodies	water_clip.shp	Baltimore City Department of Recreation & Parks
Background Aerial	NAIP_2015.jpg	USDA Farm Service Agency

Figure E: Forest Edge		
Map File Name: E_Forest_Edge.mxd		
Feature	**File Name**	**Source**
10 ft. Contours	contour_index_10ft_clip.shp	Baltimore City Department of Recreation & Parks
Forest Stands	GFLP_Stands.shp	Biohabitats
Forest Edge (50' wide)	NNI_edge_50_ByStand.shp	Biohabitats
Future Forest Edge from Future Gas Line (50' wide)	NNI_edge_50_ByStand_NewGas.shp	Biohabitats, based on Erosion and Sediment Control Plan for BGE Granite Pipeline Relocation Project (Phase 2) 26" OHP Gas Main, REV D, dated 9/16/16
Buildings	building_elevation_clip.shp	Baltimore City Department of Recreation & Parks
Property	realprop_2014_0416.shp	Baltimore City Department of Recreation & Parks
Streets	street_area_clip.shp	Baltimore City Department of Recreation & Parks
Streams	hydro_cl_clip2.shp	Baltimore City Department of Recreation & Parks
Waterbodies	water_clip.shp	Baltimore City Department of Recreation & Parks
Background Aerial	NAIP_2015.jpg	USDA Farm Service Agency

Figure G: Potential Afforestation & Deer Exclosures		
Map File Name: G_Potential_Afforestation_Deer_Exclosures.mxd		
Feature	**File Name**	**Source**
10 ft. Contours	contour_index_10ft_clip.shp	Baltimore City Department of Recreation & Parks
Potential Afforestation Areas	Management_Activities.gdb\Afforestation	Biohabitats
Potential Deer Exclosure Areas	Management_Activities.gdb\Deer_exclosures	Biohabitats
Management Units	Management Units.shp	Biohabitats
Forest Stands	GFLP_Stands.shp	Biohabitats
Buildings	building_elevation_clip.shp	Baltimore City Department of Recreation & Parks
Property	realprop_2014_0416.shp	Baltimore City Department of Recreation & Parks
Streets	street_area_clip.shp	Baltimore City Department of Recreation & Parks
Streams	hydro_cl_clip2.shp	Baltimore City Department of Recreation & Parks
Waterbodies	water_clip.shp	Baltimore City Department of Recreation & Parks
Background Aerial	NAIP_2015.jpg	USDA Farm Service Agency

Figure B-1: Sample Plot Locations		
Map File Name: X_B-1_Sample_Plot_Locations.mxd		
Feature	**File Name**	**Source**
10 ft. Contours	contour_index_10ft_clip.shp	Baltimore City Department of Recreation & Parks
A Plot: Overstory & Understory	PlotPoints_All.shp	Biohabitats
B Plot: Understory	PlotPoints_All.shp	Biohabitats
Multi-use Trails	trail_multiuse_clip_2011.shp	Baltimore City Department of Recreation & Parks
Hiking Trails	trail_hiking_GFLP_2011.shp	Baltimore City Department of Recreation & Parks
Buildings	building_elevation_clip.shp	Baltimore City Department of Recreation & Parks
Streets	street_area_clip.shp	Baltimore City Department of Recreation & Parks
Streams	hydro_cl_clip2.shp	Baltimore City Department of Recreation & Parks
Waterbodies	water_clip.shp	Baltimore City Department of Recreation & Parks
Background Aerial	NAIP_2015.jpg	USDA Farm Service Agency

Figure B-2: Slopes		
Map File Name: X_B-2_Slope.mxd		
Feature	**File Name**	**Source**
10 ft. Contours	contour_index_10ft_clip.shp	Baltimore City Department of Recreation & Parks
Streams	hydro_cl_clip2.shp	Baltimore City Department of Recreation & Parks
Waterbodies	water_clip.shp	Baltimore City Department of Recreation & Parks
Streets	street_area_clip.shp	Baltimore City Department of Recreation & Parks
Forest Stands	GFLP_Stands.shp	Biohabitats
Slope	Slope.gdb\Slope_Clipped_MU	Biohabitats
Background Aerial	NAIP_2015.jpg	USDA Farm Service Agency

Figure B-3: NNI Overstory Trees		
Map File Name: X_B-3_NNI_Over_TPA.mxd		
Feature	**File Name**	**Source**
10 ft. Contours	contour_index_10ft_clip.shp	Baltimore City Department of Recreation & Parks
Forest Stands	GFLP_Stands.shp	Biohabitats
NNI Overstory Trees/Acre	NNI_Over_TPA_Stands.shp	Biohabitats
Buildings	building_elevation_clip.shp	Baltimore City Department of Recreation & Parks
Property	realprop_2014_0416.shp	Baltimore City Department of Recreation & Parks
Streets	street_area_clip.shp	Baltimore City Department of Recreation & Parks
Streams	hydro_cl_clip2.shp	Baltimore City Department of Recreation & Parks
Waterbodies	water_clip.shp	Baltimore City Department of Recreation & Parks
Background Aerial	NAIP_2015.jpg	USDA Farm Service Agency

Figure B-4: NNI Understory Trees		
Map File Name: X_B-4_NNI_Under_TPA.mxd		
Feature	**File Name**	**Source**
10 ft. Contours	contour_index_10ft_clip.shp	Baltimore City Department of Recreation & Parks
Forest Stands	GFLP_Stands.shp	Biohabitats
NNI Understory Trees/Acre	NNI_Under_TPA_Stands.shp	Biohabitats
Buildings	building_elevation_clip.shp	Baltimore City Department of Recreation & Parks
Property	realprop_2014_0416.shp	Baltimore City Department of Recreation & Parks
Streets	street_area_clip.shp	Baltimore City Department of Recreation & Parks
Streams	hydro_cl_clip2.shp	Baltimore City Department of Recreation & Parks
Waterbodies	water_clip.shp	Baltimore City Department of Recreation & Parks
Background Aerial	NAIP_2015.jpg	USDA Farm Service Agency

Figure B-5: NNI Vines on Overstory Trees		
Map File Name: X_B-5_NNI_Vines_TPA.mxd		
Feature	**File Name**	**Source**
10 ft. Contours	contour_index_10ft_clip.shp	Baltimore City Department of Recreation & Parks
Forest Stands	GFLP_Stands.shp	Biohabitats
NNI Vines on Overstory Trees/Acre	NNI_Over_Vines_TPA_Stands.shp	Biohabitats
Buildings	building_elevation_clip.shp	Baltimore City Department of Recreation & Parks
Property	realprop_2014_0416.shp	Baltimore City Department of Recreation & Parks
Streets	street_area_clip.shp	Baltimore City Department of Recreation & Parks
Streams	hydro_cl_clip2.shp	Baltimore City Department of Recreation & Parks
Waterbodies	water_clip.shp	Baltimore City Department of Recreation & Parks
Background Aerial	NAIP_2015.jpg	USDA Farm Service Agency

Figure B-6: NNI Understory Cover		
Map File Name: X_B-6_NNI_Under_Cover.mxd		
Feature	**File Name**	**Source**
10 ft. Contours	contour_index_10ft_clip.shp	Baltimore City Department of Recreation & Parks
Forest Stands	GFLP_Stands.shp	Biohabitats
NNI Understory (3' to <10' ht) Percent Cover	NNI_Under_Cover_Stands.shp	Biohabitats
Buildings	building_elevation_clip.shp	Baltimore City Department of Recreation & Parks
Property	realprop_2014_0416.shp	Baltimore City Department of Recreation & Parks
Streets	street_area_clip.shp	Baltimore City Department of Recreation & Parks
Streams	hydro_cl_clip2.shp	Baltimore City Department of Recreation & Parks
Waterbodies	water_clip.shp	Baltimore City Department of Recreation & Parks
Background Aerial	NAIP_2015.jpg	USDA Farm Service Agency

Figure B-7: NNI Groundstory Cover		
Map File Name: X_B-7_NNI_Ground_Cover.mxd		
Feature	**File Name**	**Source**
10 ft. Contours	contour_index_10ft_clip.shp	Baltimore City Department of Recreation & Parks
Forest Stands	GFLP_Stands.shp	Biohabitats
NNI Groundstory (0' to <3' ht) Percent Cover	NNI_Ground_Cover_Stands.shp	Biohabitats
Buildings	building_elevation_clip.shp	Baltimore City Department of Recreation & Parks
Property	realprop_2014_0416.shp	Baltimore City Department of Recreation & Parks
Streets	street_area_clip.shp	Baltimore City Department of Recreation & Parks
Streams	hydro_cl_clip2.shp	Baltimore City Department of Recreation & Parks
Waterbodies	water_clip.shp	Baltimore City Department of Recreation & Parks
Background Aerial	NAIP_2015.jpg	USDA Farm Service Agency

APPENDIX A: Additional Tables

Table A-1: Canopy Closure and Density

Stand	Canopy closure (%) (>30' ht)	Midstory closure (%) (10' to 30' ht)	Native Overstory Trees/ Acre	Rel. density (%) (overstory and understory)	Medial. dbh (in) (overstory and understory)	Native Sapling Stems Per Acre (3' to 10' ht)	Aboveground Biomass (tons/ac)
Stand A	62	25	247	91	20	33	87
Stand B	53	33	198	53	20	65	52
Stand C	45	40	248	91	17	50	78
Stand D	66	36	273	90	19	145	94
Stand E	82	20	193	76	25	267	131
Stand F	85	15	290	91	16	200	117
Stand G	88	50	270	121	26	50	245
Stand H	65	43	130	66	30	0	169
Stand I	63	32	190	131	28	110	189
Stand J	48	44	380	107	26	100	142
Stand K	55	38	268	84	24	38	110
Stand L	20	80	120	30	12	0	32
Stand M	74	14	192	68	21	108	129
Stand N	74	18	253	96	22	138	141
Stand O	67	32	102	60	20	130	62
Stand P	47	55	243	78	21	33	102
Stand Q	59	28	190	94	23	100	119
Stand R	54	40	161	80	26	54	130
Stand S	80	31	286	84	24	131	133
Stand T	70	38	368	99	25	110	173
Stand U	83	58	240	134	58	13	233
Stand V	78	47	297	96	25	117	155
Stand W	71	19	145	70	22	38	73
Stand X	87	66	432	107	22	230	144

Table A-1: Canopy Closure and Density (cont.)

Stand	Canopy closure (%) (>30' ht)	Midstory closure (%) (10' to 30' ht)	Native Overstory Trees/ Acre	Rel. density (%) (overstory and understory)	Medial. dbh (in) (overstory and understory)	Native Sapling Stems Per Acre (3' to 10' ht)	Aboveground Biomass (tons/ac)
Stand Y	79	49	571	165	23	579	203
Stand Z	88	68	430	110	21	290	148
Stand AA	88	30	380	135	19	325	165
Stand BB	78	36	332	108	23	220	141
Stand CC	73	61	440	114	14	390	107
Stand DD	79	22	240	88	27	100	176
Stand EE	72	55	257	74	20	67	80
Stand FF	73	60	264	90	24	135	122
Stand GG	65	43	154	86	22	45	103
Stand HH	63	83	295	114	18	125	102
Stand Area- Weighted Average	**68**	**42**	**263**	**92**	**23**	**123**	**127**

Table A-2: Understory and Ash Summary

Stand	Total Understory Stems Per Acre (3' to 10' ht)	Ash Understory Stems Per Acre (3' to 10' ht)	% Ash (3' to 10' ht)	Total Seedlings Per Acre (<3' ht)	Ash Seedlings Per Acre (< 3' ht)	% Ash Seedlings	Ash as a Dominant Overstory Species (based on basal area)
Stand A	33	17	50%	1267	1017	80%	
Stand B	65	30	46%	400	320	80%	
Stand C	50	10	20%	310	270	87%	green ash
Stand D	145	18	12%	1041	591	57%	green ash
Stand E	267	50	19%	283	0	0%	
Stand F	200	0	0%	1200	900	75%	
Stand G	50	25	50%	288	275	96%	white ash
Stand H	0	0	0%	438	438	100%	
Stand I	110	10	9%	830	700	84%	
Stand J	100	33	33%	3850	3717	97%	white ash
Stand K	38	0	0%	1188	1113	94%	
Stand L	0	0	0%	450	450	100%	white ash
Stand M	108	8	8%	42	33	80%	
Stand N	138	0	0%	563	438	78%	
Stand O	130	0	0%	500	470	94%	
Stand P	33	0	0%	250	250	100%	white ash
Stand Q	100	17	17%	1792	1133	63%	white ash
Stand R	54	27	50%	438	381	87%	green ash
Stand S	131	0	0%	1688	1458	86%	
Stand T	110	10	9%	740	360	49%	
Stand U	13	0	0%	2800	2638	94%	
Stand V	117	0	0%	1500	1183	79%	white ash

Table A-2: Understory and Ash Summary (cont.)

Stand	Total Understory Stems Per Acre (3' to 10' ht)	Ash Understory Stems Per Acre (3' to 10' ht)	% Ash (3' to 10' ht)	Total Seedlings Per Acre (<3' ht)	Ash Seedlings Per Acre (< 3' ht)	% Ash Seedlings	Ash as a Dominant Overstory Species (based on basal area)
Stand W	38	0	0%	375	163	43%	
Stand X	230	0	0%	1300	970	75%	
Stand Y	579	0	0%	1686	857	51%	
Stand Z	290	0	0%	920	710	77%	
Stand AA	325	0	0%	550	50	9%	
Stand BB	220	0	0%	590	80	14%	
Stand CC	390	0	0%	710	10	1%	
Stand DD	100	10	10%	110	50	45%	
Stand EE	67	0	0%	233	100	43%	green ash
Stand FF	135	8	6%	554	346	62%	green ash
Stand GG	45	5	10%	168	86	51%	green ash
Stand HH	125	25	20%	100	50	50%	green ash
Stand Area-Weighted Average	**123**	**10**	**13%**	**836**	**624**	**69%**	

Table A-3: Snags and Coarse Woody Debris

Stand	Total Overstory Snags/ Acre	Percent of Overstory Trees (living and dead) that are Snags	Overstory Snags ≥12"/ Acre	Percent of Overstory Trees ≥12" (living and dead) that are Snags	Overstory Snags ≥18"/ Acre	NPS Snag Rating (Tierney et al. 2014)	Live Overstory Tree Aboveground Volume (cu ft/ac)	Coarse Woody Debris Volume (cu ft/ac)	CWD Volume/Live Tree Volume (Percent)	NPS CWD Rating (Tierney et al. 2014)
Stand A	40	13%	3	10%	0	Good	2571	587	23%	Good
Stand B	38	16%	7	22%	0	Good	1852	528	29%	Good
Stand C	38	13%	6	10%	2	Good	2697	663	25%	Good
Stand D	22	7%	6	11%	2	Caution	3313	1611	49%	Good
Stand E	7	3%	7	17%	7	Caution	3968	1796	45%	Good
Stand F	1	0%	0	0%	0	Significant Concern	4145	656	16%	Good
Stand G	13	4%	3	3%	0	Caution	8168	1116	14%	Caution
Stand H	63	31%	15	20%	0	Good	5612	1157	21%	Good
Stand I	20	8%	10	17%	6	Caution	5326	1059	20%	Good
Stand J	63	13%	0	0%	0	Significant Concern	4083	1591	39%	Good
Stand K	48	15%	3	7%	0	Caution	3070	667	22%	Good
Stand L	10	7%	0	0%	0	Significant Concern	1147	2466	215%	Good
Stand M	13	6%	2	3%	2	Caution	4622	1347	29%	Good
Stand N	5	2%	3	4%	3	Caution	4470	811	18%	Good
Stand O	8	5%	2	5%	0	Caution	2490	1102	44%	Good
Stand P	53	15%	0	0%	0	Significant Concern	3431	214	6%	Caution
Stand Q	13	7%	0	0%	0	Significant Concern	4083	837	20%	Good
Stand R	19	11%	5	8%	2	Caution	4383	765	17%	Good
Stand S	15	5%	2	2%	1	Caution	4074	1690	41%	Good
Stand T	70	15%	0	0%	0	Significant Concern	5420	1412	26%	Good
Stand U	23	8%	0	0%	0	Significant Concern	5615	1819	32%	Good
Stand V	20	6%	3	5%	3	Caution	4964	1696	34%	Good
Stand W	30	15%	3	6%	3	Caution	2774	853	31%	Good
Stand X	16	4%	2	3%	0	Caution	4269	709	17%	Good
Stand Y	53	8%	3	4%	1	Caution	5464	1970	36%	Good
Stand Z	24	5%	4	6%	2	Caution	4614	1909	41%	Good
Stand AA	30	7%	5	6%	5	Caution	4889	923	19%	Good
Stand BB	24	7%	0	0%	0	Significant Concern	3847	931	24%	Good
Stand CC	44	9%	14	19%	12	Caution	3160	1115	35%	Good
Stand DD	24	9%	2	3%	2	Caution	5791	2430	42%	Good

Table A-3: Snags and Coarse Woody Debris (cont.)

Stand	Total Overstory Snags/ Acre	Percent of Overstory Trees (living and dead) that are Snags	Overstory Snags ≥12"/ Acre	Percent of Overstory Trees ≥12" (living and dead) that are Snags	Overstory Snags ≥18"/ Acre	NPS Snag Rating (Tierney et al. 2014)	Live Overstory Tree Aboveground Volume (cu ft/ac)	Coarse Woody Debris Volume (cu ft/ac)	CWD Volume/Live Tree Volume (Percent)	NPS CWD Rating (Tierney et al. 2014)
Stand EE	43	13%	13	31%	13	Good	2408	1209	50%	Good
Stand FF	38	12%	5	9%	2	Caution	3673	924	25%	Good
Stand GG	39	19%	13	17%	1	Good	3546	1189	34%	Good
Stand HH	40	11%	30	32%	10	Good	3243	1346	41%	Good
Stand Area-Weighted Average	**31**	**10%**	**5**	**9%**	**2**	**Caution**	**4010**	**1175**	**29%**	**Good**

Table A-4: NNI Species Observed at GFLP

NED-3 Symbol	Latin Name	Common Name	Growth form	NatureServe Invasive Species Impact Rank (Morse et al. 2004, NatureServe 2017)
Trees				
ACPL	*Acer platanoides*	Norway maple	Tree	High
AIAL	*Ailanthus altissima*	tree of heaven	Tree	Medium
ALJU	*Albizia julibrissin*	silktree	Tree	Low
BRPA4	*Broussonetia papyrifera*	paper mulberry	Tree	Insignificant
ELAN	*Elaeagnus angustifolia*	Russian olive	Tree	High
HISY	*Hibiscus syriacus*	rose of Sharon	Tree	NA
MOAL	*Morus alba*	white mulberry	Tree	High
PATO2	*Paulownia tomentosa*	princesstree	Tree	Medium
RHCA3	*Rhamnus cathartica*	common buckthorn	Tree	High
Shrubs				
BETH	*Berberis thunbergii*	Japanese barberry	Shrub	High
EUAL13	*Euonymus alatus*	Siebold burningbush	Shrub	Low
LIVU	*Ligustrum vulgare*	European privet	Shrub	High
LONIC	*Lonicera*	honeysuckle	Shrub	High
RUPH	*Rubus phoenicolasius*	wine raspberry	Shrub	Medium
Subshrubs, Forbs/Herbs, Graminoids				
ALPE4	*Alliaria petiolata*	garlic mustard	Forb/herb	High
ARVU	*Artemisia vulgaris*	common wormwood	Subshrub	NA
CHMA2	*Chelidonium majus*	celandine	Forb/herb	Medium
GLHE2	*Glechoma hederacea*	ground ivy	Forb/herb	Low
LIMU6	*Liriope muscari*	big blue lilyturf	Forb/herb	NA
MIVI	*Microstegium vimineum*	Japanese stiltgrass	Graminoid	High
MISI	*Miscanthus sinensis*	Chinese silvergrass	Graminoid	Medium
OPUN	*Oplismenus undulatifolius*	wavyleaf basketgrass	Graminoid	NA
PHYLL6	*Phyllostachys*	bamboo	Subshrub	Medium
POCU6	*Polygonum cuspidatum*	Japanese knotweed	Subshrub	High
POPE10	*Polygonum perfoliatum*	Asiatic tearthumb	Forb/herb	Medium
URDI	*Urtica dioica*	stinging nettle	Forb/herb	NA
Vines				
AMBR7	*Ampelopsis brevipedunculata*	Amur peppervine	Vine	Medium
CEOR7	*Celastrus orbiculatus*	oriental bittersweet	Vine	High
EUFO5	*Euonymus fortunei*	winter creeper	Vine	High
HEHE	*Hedera helix*	English ivy	Vine	High
LOJA	*Lonicera japonica*	Japanese honeysuckle	Vine	High
PUMO	*Pueraria montana*	kudzu	Vine	Medium
ROMU	*Rosa multiflora*	multiflora rose	Vine	Medium
VIMI2	*Vinca minor*	dwarf periwinkle	Vine	Low
WIFL	*Wisteria floribunda*	Japanese wisteria	Vine	Medium

Table A-5: Species Recommendations for Afforestation and Supplemental Planting

Community Type: Mixed Floodplain Hardwoods
Stands: A, B, C, D

			Afforestation	Supplemental Underplanting
Trees:	red maple	*Acer rubrum*	X	X
	silver maple	*Acer saccharinum*	X	X
	serviceberry	*Amelanchier canadensis*		X
	river birch	*Betula nigra*	X	X
	ironwood	*Carpinus caroliniana*		X
	bitternut hickory	*Carya cordiformis*	X	
	hackberry	*Celtis occidentalis*	X	X
	American sycamore	*Platanus occidentalis*	X	X
	eastern cottonwood	*Populus deltoides*	X	
	swamp white oak	*Quercus bicolor*	X	X
	pin oak	*Quercus palustris*	X	
	willow oak	*Quercus phellos*	X	X
	American elm	*Ulmus americana*	X	
Shrubs:	smooth alder	*Alnus serrulata*	X	
	silky dogwood	*Cornus amomum*	X	X
	red-osier dogwood	*Cornus sericea*	X	
	possumhaw	*Ilex decidua*	X	X
	common elderberry	*Sambucus canadensis*	X	X
	highbush blueberry	*Vaccinium corybosum*	X	X
	arrowwood	*Viburnum dentatum*	X	X
	blackhaw viburnum	*Viburnum prunifolium*	X	X
Herbaceous:	tussock sedge	*Carex stricta*	X	X
	wild (river) oats	*Chasmanthium latifolium*		X
	Deertongue grass	*Dichanthelium clandestinum*	X	X
	Viriginia wild rye	*Elymus virignicus*	X	X
	Joe-Pye weed	*Eupatorium dubium*	X	X
	common boneset	*Eupatorium perfoliatum*	X	X
	blazingstar	*Liatris spicata*	X	
	cardinal flower	*Lobelia cardinalis*	X	X
	great blue lobelia	*Lobelia siphilitica*	X	X
	Virginia switchgrass	*Panicum virgatum*	X	
	golden ragwort	*Senecio aureus*	X	X
	coastal blue-eyed grass	*Sisyrinchium atlanticum*	X	
	wrinkle leaf goldenrod	*Solidago rugosa*	X	
	gama grass	*Tripsacum dactyloides*	X	X
	blue vervain	*Verbena hastata*	X	X

Table A-5: Species Recommendations for Afforestation and Supplemental Planting (cont.)

Community Type: Mesic Mixed Hardwoods
Stands: F, R, U, EE, GG

			Afforestation	Supplemental Underplanting
Trees:	sugar maple	*Acer saccharum*	X	X
	paw paw	*Asmina triloba*	X	
	sweet birch	*Betula lenta*	X	X
	bitternut hickory	*Carya cordiformis*	X	
	shagbark hickory	*Carya ovata*	X	
	redbud	*Cercis canadensis*	X	X
	flowering dogwood	*Cornus florida*		X
	black walnut	*Juglans nigra*	X	
	black cherry	*Prunus serotina*	X	
	white oak	*Qurecus alba*	X	
	scarlet oak	*Quercus coccinea*	X	
	red oak	*Quercus rubra*	X	X
	sassafrass	*Sassafras albidum*	X	X
	American basswood	*Tilia americana*		X
	slippery elm	*Ulmus rubra*	X	X
	American elm*	*Ulmus americana*	X	X
Shrubs:	red chokeberry	*Aronia arbutifolia*	X	
	silky dogwood	*Cornus amomum*	X	X
	maple leaf hydrangea	*Hydrangea arborescens*		X
	deciduous holly	*Ilex decidua*	X	X
	spicebush	*Lindera benzoin*	X	X
	possumhaw viburnum	*Viburnum nudum*		X
Herbaceous:	New England aster	*Aster novae-angliae*	X	X
	blue wood sedge	*Carex glaucodea*		X
	tussock sedge	*Carex stricta*	X	X
	Canada wild rye	*Elymus canadensis*	X	
	bottlebrush grass	*Elymus hystrix*	X	X
	Virginia wild rye	*Elymus virginicus*		X
	Wild blue lupine	*Lupinus perennis*	X	X
	Virginia switchgrass	*Panicum virgatum*	X	
	Virginia bluebells	*Mertensia virginica*	X	X
	wild bergamot	*Monarda fistulosa*	X	
	ox-eye sunflower	*Heliopsis helianthoides*	X	X
	rigid goldenrod	*Solidago rigida*	X	
	showy goldenrod	*Solidago speciosa*	X	X
	blue-stem goldenrod	*Solidago caesia*	X	X

*Future disease-resistant variety

Table A-5: Species Recommendations for Afforestation and Supplemental Planting (cont.)

Community Type: Upland Mixed Hardwoods

Stands: E, G, H, I, J, K, L, M, N, O, P, Q, S, T, V, W, X, Y, Z, AA, BB, CC, DD, FF, HH

			Afforestation	Supplemental Underplanting
Trees:	mockernut hickory	*Carya alba*		X
	pignut hickory	*Carya glabra*	X	X
	American chestnut*	*Castanea dentata*	X	
	redbud	*Cercis canadensis*	X	X
	fringetree	*Chionanthus virginicus*	X	X
	persimmon	*Diospyros virginiana*	X	X
	American beech	*Fagus grandifolia*		X
	black gum	*Nyssa sylvatica*	X	X
	white oak	*Quercus alba*	X	
	chestnut oak	*Quercus prinus*	X	X
	red oak	*Quercus rubrum*	X	X
	black oak	*Quercus velutina*	X	
Shrubs:	witchhazel	*Hamamelis virginiana*	X	X
	mountain laurel	*Kalmia latifolia*		X
	staghorn sumac	*Rhus typhina*	X	
	lowbush blueberry	*Vaccineum angustifolium*	X	X
	early lowbush blueberry	*Vaccineum pallidum*	X	X
	mapleleaf viburnum	*viburnum acerifolium*		X
Herbaceous:	broomsedge	*Andropogon virginicus*	X	
	common milkweed	*Asclepias syriaca*	X	
	butterflyweed	*Asclepias tuberosa*	X	X
	smooth blue aster	*Aster laevis*	X	
	white heath aster	*Aster pilosus*	X	X
	wild indigo	*Baptisia tinctoria*	X	
	blue wood sedge	*Carex glaucodea*		X
	Pennsylvania sedge	*Carex pensylvanica*		X
	Maryland golden aster	*Chrysopsis mariana*	X	
	panicled tick-trefoil	*Desmodium paniculatum*	X	
	Canada wild rye	*Elymus canadensis*	X	
	bottlebrush grass	*Elymus hystrix*	X	X
	white snakeroot	*Eupatorium rugosum*		X
	woodland sunflower	*Helianthus divaricatus*		X
	grass-leaf blazingstar	*Liatris graminifolia*	X	
	horsemint	*Monarda punctata*	X	
	black-eyed Susan	*Rudbeckia hirta*	X	
	little bluestem	*Schizachyrium scoparium*	X	X
	blue-stem goldenrod	*Solidago caesia*	X	X
	gray goldenrod	*Solidago nemoralis*	X	X
	rigid goldenrod	*Solidago rigida*	X	
	showy goldenrod	*Solidago speciosa*	X	X

*Future disease-resistant variety

APPENDIX B: Additional Maps

Gwynns Falls
Forest Management Plan
Baltimore, MD

Figure B-1: Sample Plot Locations

Legend

PLOTTYPE

- A Plot: Overstory & Understory
- B Plot: Understory
- 10 ft. Contours
- Multi-use Trails
- Hiking Trails
- Buildings
- Streets
- Streams
- Waterbodies
- Forest
- Lawn/ Grasses

0 500 1,000 1,500 Feet

N

Biohabitats

October 2017

Document Path: W:\GIS\PROJECTS\16029.01 GFLP Forest Management Plan\MXD\ReportMaps_FINAL\X_B-1_Sample_Plot_Locations.mxd

Gwynns Falls

Forest Management Plan

Baltimore, MD

Figure B-2: Slopes

Legend

- 10 ft. Contours
- Streams
- Waterbodies
- Streets
- A — Forest Stands

Slope

- 0 - 5%
- 5 - 15%
- 15 - 25%
- > 25%

0 500 1,000 1,500 Feet

N

Biohabitats

October 2017

Document Path: W:\GIS\PROJECTS\16029.01 GFLP Forest Management Plan\MXD\ReportMaps_FINAL\X_B-2_Slopes.mxd

Gwynns Falls
Forest Management Plan
Baltimore, MD

Figure B-3: NNI Overstory Trees

Legend

10 ft. Contours

A Forest Stands

NNI Overstory Trees/Acre

0

1 - 14

15 - 49

50 - 67

0 500 1,000 1,500 Feet

N

Biohabitats

October 2017

Document Path: W:\GIS\PROJECTS\16029.01 GFLP Forest Management Plan\MXD\ReportMaps_FINAL\X_B-3_NNI_Over_TPA.mxd

Gwynns Falls
Forest Management Plan

Baltimore, MD

Figure B-4: NNI Understory Trees

Legend

10 ft. Contours

A Forest Stands

NNI Understory Trees/Acre

- 0
- 1 - 15
- 16 - 49
- 50 - 60

0 500 1,000 1,500 Feet

N

Biohabitats

October 2017

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Gwynns Falls

Forest Management Plan

Baltimore, MD

Figure B-5: NNI Vines on Overstory Trees

Legend

10 ft. Contours

A — Forest Stands

NNI Vines on Overstory Trees/Acre

- 0
- 1 - 14
- 15 - 99
- 100 - 286

0 500 1,000 1,500 Feet

N

Biohabitats

October 2017

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Gwynns Falls
Forest Management Plan
Baltimore, MD

Figure B-6: NNI Understory Cover

Legend

10 ft. Contours

A — Forest Stands

NNI Understory (3' to <10' ht) Percent Cover

- 0%
- 1% - 4%
- 5% - 24%
- 25% - 30%

0 500 1,000 1,500 Feet

N

Biohabitats

October 2017

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Gwynns Falls

Forest Management Plan

Baltimore, MD

Figure B-7: NNI Groundstory Cover

Legend

10 ft. Contours

A — Forest Stands

NNI Groundstory (0' to <3' ht) Percent Cover

- 1% - 4%
- 5% - 24%
- 25% - 76%

0 500 1,000 1,500 Feet

N

Biohabitats

October 2017

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APPENDIX C: Best Management Practices

One of the primary drivers of disturbance and invasion biology in many park parcels is the operational procedures followed during maintenance activities. Relatively minor changes in field operations, such as modifications in mowing timing, mowing sequence and vehicle cleaning, can yield major returns on reduced infestations and, ultimately, avoided expenditures for intervention.

The following is a list of operational procedures to assist in the prevention, control, and eradication of NNIP on City maintained properties.

BMP 1: Minimize the area and intensity of ground disturbance associated with construction and/or maintenance activities.

Rationale: Disturbance of the soil facilitates the establishment of invasive plants. For example, stiltgrass can become established along trails following their construction then spread into adjacent forest land. Minimizing such disturbance will help minimize the area susceptible to establishment of invasive plants. Ground disturbance can be minimized during the project planning process by clearly delineating zones in which heavy equipment can operate. Language can be incorporated in contracts that establish penalties for contractors that operate heavy equipment outside of permitted zones.

BMP 2: Control invasive plant species in areas to be disturbed prior to disturbance.

Rationale: During construction and maintenance activities, seeds and fragments of invasive plants can be spread throughout the disturbed site. The disturbance also facilitates the establishment of invasive plants through processes such as increasing soil seed contact, increasing light availability, and reducing competition. Pre-construction or pre-maintenance invasive plant control is especially important in situations where only a few invasive plants are already present, because these can be killed prior to disturbance or when an invasive plant species that is a high-priority for control is present. Pre-construction or maintenance plant control would likely employ herbicides. Control should occur early enough such that the invasive plants are dead when construction or maintenance begins and should be part of the project budget.

BMP 3: Inspect and clean plant materials and soil from all pieces of heavy construction equipment (e.g., loaders, graders, backhoes, bulldozers) prior to their entry on parklands.

BMP 3.1: Clean maintenance equipment prior to operating in areas currently uninvaded by NNI species.

BMP 3.2: Schedule daily operations in areas of low NNI infestation first in order to reduce the need for multiple vehicle cleanings during the work day.

Rationale: Seeds or living fragments of invasive plant species that are capable of establishing new plants can lodge in the tracks, wheels, or undercarriages of heavy equipment. Such seeds and plant fragments can be transported from one location to another on the equipment. Inspecting and removing plant fragments will reduce the likelihood of introducing invasive plants to new locations. Water from high-pressure hoses or leaf blowers is particularly effective in dislodging seeds and plant fragments from heavy equipment. Language can be incorporated in contracts that require contractors to clean heavy equipment prior to working on City parcels.

BMP 4: Promptly revegetate all significant disturbances resulting from construction and/or maintenance activities.

Rationale: Minimizing the time that disturbed soil remains bare will help minimize the likelihood that non-native invasive plants will be able to colonize a disturbed site. Language should be incorporated in contracts that require contractors to re-seed disturbed areas within 7 days following cessation of ground-disturbing activities.

BMP 5: Re-seed disturbed areas with a diverse mixture of desirable native plant species suitable to the disturbed site.

Rationale: Re-seeding is important because it speeds the rate at which disturbed areas are revegetated and helps suppress invasive plant species. We recommend that the City specify seed mixes for different environmental conditions and require contractors to use one (or more if appropriate) of the approved seed mixes.

BMP 5.1: Seed and establish native warm season grass communities on open afforestation sites.

Rationale: Afforestation sites are often only planted with woody plants. However, until woody plants get tall enough and the canopy closes, there will be a great deal of light and intense competition from non-woody plants. By establishing a healthy community of native warm season grasses and forbs, non-native invasive plant occurrence can be minimized and the wildlife benefit greatly increased. This will mimic an old field habitat until the woody plants mature. A

certified weed free compost blanket may additionally speed up natural system recovery and ground stability.

BMP 6: Utilize weed-free straw/mulch on construction and/or maintenance projects where mulch is specified.

Rationale: Mulches are commonly used to promote plant establishment. However, straw and other wood mulches can harbor seeds of non-native invasive plants. Where mulching is specified it should be free of NNI plant seeds and propagules. North American Weed Management Association standards for weed free forage and mulch should be followed where possible.

BMP 7: Use native plant species instead of non-invasive introduced plant species for landscaping parklands.

Rationale: It is counterproductive to use invasive plants for landscaping or wildlife habitat purposes regardless of any aesthetic value that they may have. Examples of such invasive plant species include Amur Honeysuckle, Russian olive, and Bradford pear. The City could create a list of approved landscaping plant species for parklands like the one currently used in the Prince George's County Landscape Manual (2010).

BMP 8: Monitor areas disturbed during new construction or maintenance activities for at least two growing seasons and control any high-priority invasive plant species that appear.

Rationale: In spite of preventative measures used during and after construction, invasive plants may appear in disturbed areas. It will be much more cost-effective in the long run to control high-priority invasive species as soon as they do appear rather than waiting until they become firmly established. Depending on the presence of invasive species in adjacent and nearby areas, it may not be reasonable to control all invasive plant species in disturbed areas. We recommend focusing management actions on high-priority invasive plant species.

BMP 9: Preserve existing canopy cover during park infrastructure modifications.

Rationale: Early successional invasive plant species have a competitive advantage in canopy gaps that increase light levels on the forest floor. Tree conservation during park renovations or improvements will minimize changes in ambient light levels.

BMP 10: Preserve existing hydrologic regime during park infrastructure modifications.

Rationale: Changes in surface flow and soil moisture levels can result in increased opportunities for invasive plant activity due to both a decline in the tree canopy on a given site and the transportation of undesirable plant propagules.

BMP 10.1: Restore hydrology where appropriate and feasible.

Rationale: Many floodplains in suburban parks have been cut off from their streams through channel incision. The result is a drier condition with periodic scour and human disturbance that is often favorable to non-native invasive species. By reconnecting the floodplain with the stream, increased overall moisture combined with lower levels of human disturbance and lower relative scour during flood events may favor native wetland and or facultative species and help restore wetland communities. Also, address stormwater runoff erosion, gullying and head-cut formation in first order tributary streams.

See the following for additional reference information:

U-1 Urban Stormwater Retrofits Fact Sheet, Cheseapeake Stormwater Network. 2015.
http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2015/06/U1.-Urban-Stormwater-Retrofits-Fact-Sheet-in-Chesapeake-Bay-Watershed.pdf

U-4 Urban Stream Restoration Fact Sheet, Cheseapeake Stormwater Network. 2015.
http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2015/06/U4.-Urban-Stream-Restoration-Fact-Sheet-in-Chesapeake-Bay-Watershed.pdf

BMP 11: Reduce vectoring of NNI species onto park lands from neighboring properties.

Rationale: NNI species do not recognize legal property boundaries. Undesirable vegetation on lands adjacent to park boundaries can act as a potential seed and vegetative propagule source resulting in infiltration of NNI species onto park property. In addition, encroachment onto park property through the direct disposal of yard waste can introduce NNI species. Monitoring park boundaries and targeting adjacent residential areas for community education and partnership offers a low-cost intervention tactic that can potentially reduce vectoring and increase community involvement in local parks.

BMP 12: Minimize site disturbance and vectoring of NNI species associated with park visitation.

Rationale: Concentrated impacts of park visitation and/or the direct, unintentional introduction of invasive propagules by park patrons can create new opportunities for NNI species establishment within park boundaries. Identification of these pathways, along with monitoring and public education can assist in reducing the impact of this vectoring mechanism.

BMP 13: Control soil erosion during NNI removal and other management activities.

Rationale: Soil disturbance and vegetation removal increase the likelihood of water and wind driven soil erosion. The minimum standard of care for soil erosion control includes minimizing soil disturbance with equipment, seeding and mulching disturbed bare soil areas, installing native planting in voids left by NNI removal, and meeting all applicable regulatory requirements.