Final Progress Report

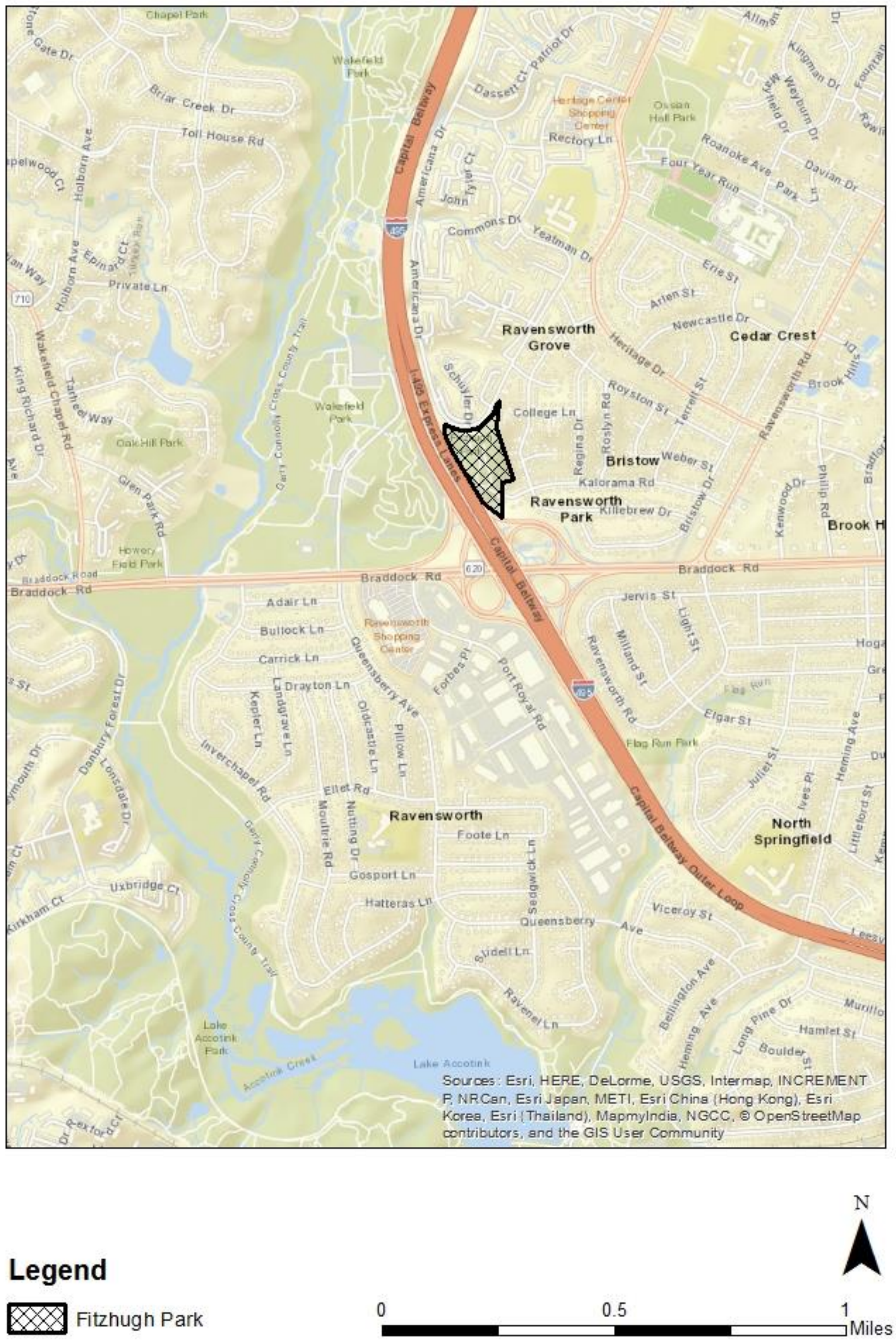
Fitzhugh Park Ecological Restoration

Overview

A Helping Our Land Heal (HOLH) project was implemented at Fitzhugh Park (Fitzhugh) from 2017 to 2020 with the goal of restoring natural communities as identified in the Fitzhugh Park Forest Treatment Plan (2011). Fairfax County Park Authority (FCPA)'s Natural Resource Branch (NRB) managed the project as part of the agency's HOLH ecological restoration program. The project complies with the Fitzhugh Park Master Plan (1984). The project contributed to achieving actions 16 through 19 in the FCPA natural resource management plan (NRMP) (2014). The objectives of the planned restoration were to restore and/or enhance ecological attributes as defined by the Society for Ecological Restoration (SER) and restore natural communities appropriate to each restoration unit's site conditions. Planned treatment would cover three acres, of which 2.6 acres were forested and 0.6 acres were meadow.

Project Maps

Fitzhugh Park



Fitzhugh Park Ecological Restoration
Final Restoration Units

Timeframe

A restoration plan was created by HOLH program staff in May 2017 as a framework for project implementation. Funding was secured in 2014 from Virginia Department of Transportation (VDOT) as part of a mitigation fund for the I-495 Express Lane expansion. A Woodland Management Plan was developed by Larry Weaner Landscape Associates in Fall 2017, which provided restoration design and management recommendations. Project implementation began in Fall 2017. Installation was mostly completed in December 2020. Remaining funds are planned for establishment of restoration plantings and treatment of invasive plants throughout 2021.

Defining the Problem

Invasive plant encroachment, low native plant biodiversity, and lack of forest structural diversity characterized the primary problems on the restoration site prior to treatments. These problems are likely a result of degrading influences that are ubiquitous throughout Fairfax County, such as forest fragmentation, white-tailed deer overpopulation, urban stormwater runoff, yard waste dumping, and land use history. Historical aerial imagery reveals that areas currently holding high-quality forest within the park have remained in continuous hardwood forest cover as far back as 1937. Restoration treatment units were either cleared for agriculture or occupied by early successional conifer trees prior to 1960, suggesting that land use history is a significant degrading factor on this site. White-tailed deer browse is severe in Fitzhugh Park, preventing regeneration of native trees, shrubs, and herbs. The northern and eastern boundaries of the park are bordered by residential properties, many of which contribute trash and yard waste to the park. Invasive plant species are particularly problematic along these boundaries. Finally, Fitzhugh Park is a small forest fragment within a heavily urbanized landscape. These degrading pressures have prevented the restoration sites from recovering naturally, and active restoration was needed to restore a healthy degree of forest structure and biodiversity.

The Society for Ecological Restoration (SER) developed a recovery scale to characterize the results of ecological restoration projects in their publication, International Standards for the Practice of Ecological Restoration (2016). The scale measures 6 key attributes relative to a set of reference community conditions. Although all attributes are relevant to ecological health, not all attributes can be addressed by small-scale restoration actions. Only attributes in ***<u>underlined italics</u>*** were directly addressed by this restoration project. The HOLH project manager characterized the pre-treatment problems at Fitzhugh using this scale. A narrative assessment was done, rather than using the SER quantitative "Five Star System":

- Absence of threats:
    - ***<u>Contamination</u>***: The northeastern portion of the park was used as an orchard in the 1930s as suggested by historic aerial imagery. Due to high

levels of arsenic in pesticides used at the time, arsenic contamination was suspected. This is based on information from a report by Larry Weaner Landscape Associates developed for the Fitzhugh Project titled Woodland Management Specifications, 2018.

  - Over-utilization: Although trails through Fitzhugh are heavily used, there is little evidence of over-utilization in the park's natural areas.
  - ***Invasive species***: Most of the shrub and herbaceous strata are dominated by non-native invasive species. Excessive white-tailed deer browse, stormwater drainage, and yard waste dumping most likely exacerbate invasive species encroachment.
- Physical conditions:
  - Water chemo-physical: Excessive stormwater drainage from adjacent developed areas. Although water tests were not conducted, it is plausible that stormwater carries chemical contaminants into the park.
  - ***Substrate physical***: Two drainages within the park receive stormwater from adjacent development, causing soil erosion.
  - Substrate chemical: Soil pH was elevated above reference community levels, possibly as a legacy of agricultural use.
- Species composition:
  - ***Desirable plants***: Many characteristic native species are present in the canopy and midstory. Only a handful of species, such as *Polystichum acrostichoides* (Christmas fern), are present in the herbaceous layer. The shrub layer is similarly low in native diversity.
  - Desirable animals: Several generalist wildlife species that are common in eastern deciduous forests are frequently seen in Fitzhugh Park, including *Odocoileus virginianus* (white-tailed deer) and *Sciurus carolinensis* (eastern gray squirrel). Due to Fitzhugh Park's small size and urban landscape context, the park is unlikely to support anything other than generalists.
  - ***No undesirable species***: Presence of non-native species was significant, with most of the shrub and herbaceous strata dominated by non-native invasive species.
- Structural diversity:
  - ***All vegetation levels***: While overstory, midstory, shrub, and herbaceous strata were all present, only the overstory was dominated by native plant species. The midstory had a few characteristic native species but was generally lacking native tree regeneration. Shrub and herbaceous layers were overwhelmingly dominated by invasive species.
  - All trophic levels: N/A
  - ***Spatial mosaic***: On a local scale, Fitzhugh Park is relatively uniform, consisting mostly of mature mixed mesic hardwood forest with relatively little habitat heterogeneity.
- Ecosystem functionality:
  - Productivity/cycling: N/A

- *__Habitat & interactions__*: Evidence of provision of habitat resources for several common wildlife species, including mast, browse, and winter cover. Large snags are scattered throughout the park, providing habitat for woodpeckers and other snag-dependent wildlife.
- *__Resilience/recruitment__*: Natural tree regeneration and perpetuation of native flora was severely impaired by white-tailed deer browse and isolation from nearby plant communities, limiting the ability of the forest community to perpetuate itself. Severe downcutting in the stream at the southern tip of the park, caused by stormwater, has likely altered hydrology in the adjacent riparian forest community and impacted the ability of riparian plants to persist.

Heavy invasion of bush honeysuckle (*Lonicera maackii*) in ManagementUnit 1, with low cover and diversity of native understory plants. Similar conditions existed throughout Units 1, 2, and 3 prior to restoration treatments.

- External exchanges:
  - Habitat links: Although it is possible that propagules dispersed by wind, surface water, birds, and mammals are exchanged with nearby forest stands, habitat links for gravity and ant-dispersed plant propagules are virtually non-existent.
  - Gene flows: Gene flow between plant populations is likely minimal for gravity and ant-dispersed plants due to lack of dispersal corridors. There

may be some gene flow for plants with propagules dispersed by wind, water, mammals, and birds. Surrounding urban areas are likely inhospitable for many insect pollinators, so pollen dispersal and gene flow for insect-pollinated plants may be limited.

- Landcape flows: N/A

Planning and Design

The overall goal of the project was to restore native plant structure, composition, and functioning to the greatest extent possible. Natural communities, as defined by the Virginia Department of Conservation and Recreation's (DCR) Natural Heritage Program, were used as restoration targets. When planning began in 2017, ten separate management units were identified. As planning and implementation proceeded, several management units were either modified or dropped from the project. Final management units are shown in the attached map "Final Management Units".

Restoration targets were developed for each unit using data from a variety of sources. Historic aerial imagery was examined to evaluate site history and successional history. Data on site conditions such as landform, aspect, soils, hydrology, and geographic setting were collected. Existing vegetation throughout the entire park was evaluated by HOLH staff with the assistance of the NRB botanist. Finally, feasibility of different management actions was considered. For example, establishing a forest community was infeasible in Unit 4 due to the existing power line easement.

Data on site conditions, vegetation, and management feasibility were compiled and compared with VADCR's database of Virginia Natural Communities. Three separate restoration target communities were identified for Fitzhugh Park:

Northern Coastal Plain/Piedmont Mesic Mixed Forest (CEGL006075): These mixed hardwood forests occur on a variety of landforms throughout the Virginia Piedmont and Northern Coastal Plain on mesic sites with deep, acidic, nutrient-poor soils. Dominant canopy trees include tuliptree (*Liriodendron tulipifera*), American beech (*Fagus grandifolia*), red oak (*Quercus rubra*), and white oak (*Quercus alba*). American holly (*Ilex opaca*) and Christmas fern (*Polystichum acrostichoides*) are dominant in the shrub and herbaceous layers, respectively.

This is the dominant upland forest type among high-quality forest stands in Fitzhugh Park, and was chosen as a target community for Units 1, 2, 2S, and 3. Goals differed by unit. The goal of Units 1 and 2 was primarily canopy restoration, with an emphasis on increasing the oak component. The goal of unit 2S and 3 was primarily understory restoration.

High-quality example of a Piedmont Mesic Mixed Forest (CEGL006075) similar to undisturbed mature forest in Fitzhugh Park. This community type was used as a target for restoration units.

Northern Piedmont Small Stream Floodplain Forest (CEGL006492): These forests occupy temporarily flooded habitats along small-order streams. Characteristic canopy trees include tuliptree (*Liriodendron tulipifera*) and sycamore (*Platanus occidentalis*). Boxelder (*Acer negundo*) is dominant in the midstory. The herbaceous layer is diverse and characterized by Virginia knotweed (*Polygonum virginianum*).

This was chosen as the target community for Units 8 and 9, which are adjacent to a historic stream visible in 1953 aerial imagery. Sometime between 1953 and 1972, the stream was channelized and diverted underground to facilitate construction of I-495 and adjacent residential areas. The remaining exposed stream in Fitzhugh has been converted to a stormwater ditch about 100 feet long and deeply incised. The area no longer floods, and the hydrology of the former floodplain has been irreversibly altered. Despite this, floodplain species associated with CEGL006492 still occupied the site when the restoration project began. Because of the altered hydrology, CEGL006492 was used as a general guide rather than a firm restoration target.

Large patch of native trout lily (*Erythronium americanum*) within undisturbed area of Fitzhugh Park.

Piedmont Prairie (CEGL006572): This is the only extant grassland community categorized by Virginia Division of Natural Heritage in the Virginia Piedmont. Occurrences of this natural community are semi-natural and have developed under a regime of frequent mowing and/or burning. Vegetation composition is very diverse, and characteristic species include Indiangrass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparium*), narrowleaf mountain mint (*Pycnanthemum tenuifolium*), and early goldenrod (*Solidago juncea*).

This community was chosen as a restoration target for Unit 4, mostly due to management restrictions associated with the power line easement that runs through this area. Unit 4 must remain accessible to heavy equipment on a semi-annual basis, making restoration of a grassland community more practical than a forest community. Because CEGL006572 is a semi-natural community, it was used as a general guide rather than a firm restoration target.

Other: Units 6 and 7 received restoration treatments but were not associated with a particular natural community target. Unit 6 is a small stormwater outfall area that experiences frequent erosive events; the goal was to establish dense native herbaceous vegetation. Unit 7 is a forested drainage that receives stormwater from adjacent residential areas; the goal was to stabilize soil and prevent head cut erosion within the drainage.

Project Activities

Project activities that were implemented in the field can be generally categorized as removal; site preparation; soil amendment; planting; and establishment activities. Specific activities are as follows:

<u>Invasive and Undesirable Vegetation Removal:</u>

- Herbicide applications – Foliar applications were made to undesirable herbaceous and short/low woody vegetation. Stem applications were made to cut stumps or to girdle cuts (“hack and squirt”) for larger plants that could not be safely or effectively treated with foliar applications.

Unit 1 following removal of invasive thickets with a forestry mulcher. Units 2 and 3 received the same treatment in preparation for planting and seeding natives.

- Forestry mulching – Undesirable woody stems were mulched into wood chips and left on-site using a skidsteer mounted forestry mulching attachment. Depending on the size and density of stems being mulched, the wood chip layer ranged from sparse to over two inches thick.
- Mowing – Undesirable woody and herbaceous vegetation was mowed using a walk-behind bush hog mower. This method is effective for dense but low-growing herbaceous vegetation and thickets of small-diameter woody vegetation.
- String trimming – Undesirable herbaceous vegetation was removed using a string trimmer. This method is most effective for annual invasives that rely on seed production to perpetuate their populations. String trimming is suitable for small patches of vegetation and must be timed correctly.
- Hand removal – Undesirable vegetation was removed using a variety of hand tools. Widely scattered invasive woody stems were removed with weed wrenches and hand saws. Small patches of invasive herbaceous plants were hand pulled.

Harley rake being used to prepare soil for seeding in Unit 1. The machine creates a good seedbed for native herbaceous plants by exposing and fluffing the top ½ inch of mineral soil.

Site Preparation:

- Power landscape raking (Harley raking) –The top ½ of soil was tilled and fluffed to eliminate litter and expose bare soil for seeding using a specialized piece of equipment called a Harley rake mounted on walk behind skid steer equipment (Dingo brand). This equipment is not powerful enough to expose soil where a thick layer of mulch exists.
- Tractor raking (York raking) – Litter and woody debris too thick for a Harley rake was removed using a York brand tractor rake. Debris was gathered into centralized piles and allowed to decompose over several seasons.
- Leaf blowing – Light leaf litter was removed using a leaf blower to expose mineral soil. This method is time-intensive and only suitable for small areas.

Planting/Seeding:

- Hand broadcast seeding – Seeding by hand, covered extensively in the restoration literature. Seed was mixed with either vermiculite or wood shavings as a carrier.

Native herbaceous vegetation germinating and establishing strongly in Unit 1 following seeding in Fall 2018. Photo was taken in Spring 2019.

- Container/plug planting – Containerized woody and herbaceous stock, ranging from plug-sized to 7-gallon, was planted using hand tools. This is a reliable method of establishing plants, although more expensive and labor-intensive than bare-root plantings.
- Bare-root planting – Bare-root woody stock was installed using hand tools. Stems were generally 1-3 feet tall with vigorous root systems. This method of planting is cost-effective and scalable for large projects, although survival and establishment may be poorer than with container plants.

Vigorous root system of a bare-root white oak (*Quercus alba*) seedling. About 250 oaks were planted in Unit 1 in December 2020.

<u>Erosion Control:</u>

- Straw mulch – A thin layer of straw mulch was spread over seeded areas that were prone to erosion. Mulch was spread so that some erosion control was provided while still allowing light to reach mineral soil for seed germination.
- One-rock dams – Small rock structures were built in the forested drainage of Unit 7 using surge stone (gravel that is about 1.5′′ to 4′′ in diameter or about the

size of a softball). The purpose of these dams is to slow stormwater flow, reduce erosion, and encourage sediment deposition. These structures are discussed in Let the Water do the Work by Bill Zeedyk and Van Clothier (Chelsea Green Publishing, 2014).

- Zuni bowl – A plunge-pool was built into a large migrating headcut in the forested drainage of Unit 7 using surge stone and class I rip rap (about 10'' in diameter). The purpose of this structure is to dissipate stormwater energy, encourage deposition, and halt migration of the existing headcut. This structure is also discussed in Let the Water do the Work.

Newly installed Zuni bowl disperses stormwater energy and encourages sediment deposition. This structure was installed in 2017 to stabilize a migrating headcut in Unit 7.

Deer Deterrence:

- Scent/flavor-based deterrents – Garlic sticks and deer-deterrent spray were used on large containerized plantings. These products are meant to deter deer and protect plantings through unpleasant scents and tastes.

- Plant cages – Cages made of 4″x2″ welded-wire mesh were constructed around containerized plantings and staked to the ground using wooden stakes. Cages for individual woody plants ranged from 18-24″ diameter and were 5′ tall. Cages about 8′ in diameter were built around clumps of containerized herbaceous plantings.

Welded-wire cages were installed over plantings in Unit 2 in Summer 2019. Cages were mostly effective at preventing deer browse, although growing tips that escaped the cage were browsed.

- Tree tubes – 5′ tall tree tubes were installed on both containerized and bare-root plantings and staked to the ground using wooden stakes. Two types of tree tubes were used: TubeX Shelterguard tubes, and open-mesh "Rigid Seedling Protector Tubes".

<u>Establishment</u>:

- Mowing – During the first season of growth of herbaceous seedlings, vegetation that reached 12′′ tall was mowed to 6′′ tall as many times as necessary until late September. This allowed light and space for slow growing perennial seedlings to establish despite competition from fast growing annuals and aggressive perennials. Mowing was done with a string trimmer.

- Herbicide – Spot foliar applications to aggressive NNI in establishing stands of woody plantings and herbaceous seedlings.
- Deer deterrent maintenance – Tree tubes and cages were maintained and repaired as needed. Growing tips of plants that escaped tubes/cages were placed back inside. Scent/flavor-based deterrents were reapplied as needed.

Mixed bare-root planting of trees and shrubs typically found in Piedmont Mesic Mixed Hardwood forests. TubeX Shelterguard tubes should provide protection from deer, while allowing adequate light to reach young seedlings.

Activity Schedule:

Parkwide (outside of restoration areas)

- 4/2018 - Hand pulled garlic mustard
- 11/2018 – Cleaned up all trash
- 4/2019 – Hand pulled garlic mustard
- 3/2020 – Pulled and cut invasive bird cherry
- 4/2020 – Hand pulled garlic mustard
- 6/2020 – Implemented cut-and-treat herbicide treatment on large widely-scattered invasive stems
- 9/2020 – String trimmed Japanese stiltgrass

Unit 1

- 4/2018 – Forestry mulched existing thickets of woody invasives

- 7/2018 – Applied foliar herbicide to vegetative regrowth and other invasives
- 9/2018 – York raked and piled debris in preparation for seeding
- 10/2018 – Applied foliar herbicide to undesirable vegetation
- 11/2018 – Harley raked and seeded with native herbaceous mix
- 4/2019 – Hand pulled garlic mustard
- 4/2020 – Hand pulled garlic mustard
- 12/2020 – Installed bare-root woody plantings, installed tree tubes

Unit 2

- 4/2018 – Forestry mulched existing thickets of woody invasives
- 7/2018 – Applied foliar herbicide to vegetative regrowth and other invasives
- 9/2018 – York raked and piled debris in preparation for seeding
- 10/2018 – Applied foliar herbicide to undesirable vegetation
- 10/2018 – Used grapple bucket to remove trees felled by FCPA forestry crew
- 11/2018 – Spot sprayed English ivy and Japanese honeysuckle; FCPA staff labor
- 11/2018 – Harley raked and seeded with native herbaceous mix
- 11/2018 – Installed containerized woody and herbaceous plantings, protected with garlic sticks and Plantskydd
- 4/2019 – Hand pulled garlic mustard
- 5/2019 – String trimmed establishing vegetation
- 6/2019 - Installed tree cages on all containerized plantings
- 7/2019 – String trimmed establishing vegetation
- 9/2019 – String trimmed establishing vegetation

Unit 2S

- 4/2018 - Hand pulled garlic mustard
- 7/2018 – Applied foliar herbicide to invasive vegetation
- 4/2019 – Hand pulled garlic mustard
- 4/2019 – Installed containerized woody plantings, installed tree cages and tubes
- 5/2019 – Installed containerized herbaceous "mother colonies", installed cage around each colony
- 4/2020 – Hand pulled garlic mustard

Unit 3

- 4/2018 - Forestry mulched existing thicket of oriental bittersweet
- 7/2018 – Applied foliar herbicide to vegetative regrowth and other invasives
- 10/2018 – Applied foliar herbicide to undesirable vegetation
- 4/2019 – Installed herbaceous woody plantings, installed tree cages and tubes
- 6/2020 – Applied foliar herbicide to undesirable vegetation
- 9/2020 – String trimmed Japanese stiltgrass

Unit 4

- 9/2017 - Bush hogged existing thicket of porcelain berry and blackberry
- 10/2017 – Applied foliar herbicide to vegetative regrowth
- 7/2018 – Applied foliar herbicide to vegetative regrowth and other invasives
- 9/2018 – York raked and piled debris in preparation for seeding
- 9/2018 – Spread four bales of straw in drainage to protect soil from heavy rain

- 10/2018 – Applied foliar herbicide to undesirable vegetation
- 10/2018 – Installed silt fence adjacent on edge of meadow adjacent to sidewalk
- 11/2018 – Spot sprayed mugwort and curly dock; FCPA staff labor
- 11/2018 – Harley raked and seeded with native herbaceous mix, spread straw mulch for erosion control
- 4/2019 – String trimmed establishing vegetation
- 5/2019 – String trimmed establishing vegetation
- 6/2019 – String trimmed establishing vegetation
- 7/2019 – String trimmed establishing vegetation
- 9/2019 – String trimmed establishing vegetation
- 6/2020 – Applied foliar herbicide to undesirable vegetation
- 9/2020 – String trimmed Japanese stiltgrass
- 11/2020 – Installed containerized herbaceous plantings for additional diversity

Unit 6

- 4/2018 - Hand pulled garlic mustard
- 4/2018 – Began artificial stratification of seed
- 6/2018 – Prepared site with leaf blower, seeded unit with stratified seed
- 4/2019 – Hand pulled garlic mustard
- 4/2020 – Hand pulled garlic mustard

Unit 7

- 9/2017 – Began installing one-rock dam features
- 10/2017 – Continued one-rock dam installation, began Zuni bowl installation
- 10/2017 – Installed herbaceous plugs directly downstream of one-rock dams
- 12/2017 – Finished installing Zuni bowl and one-rock dams
- 6/2018 – Repaired washed-out dam structures

Unit 8

- 4/2018 - Forestry mulched existing thicket of invasives and cut declining green ash and black locust trees
- 4/2018 - Hand pulled garlic mustard
- 7/2018 – Applied foliar herbicide to vegetative regrowth and other invasives
- 9/2018 – York raked and piled debris in preparation for seeding
- 10/2018 – Applied foliar herbicide to undesirable vegetation
- 11/2018 – Harley raked and seeded with native herbaceous mix
- 11/2018 – Installed containerized woody and herbaceous plantings, protected with garlic sticks and Plantskydd
- 4/2019 – Hand pulled garlic mustard
- 6/2019 - Installed tree cages on all containerized plantings
- 7/2019 – String trimmed establishing vegetation
- 9/2019 – String trimmed establishing vegetation
- 4/2020 – Hand pulled garlic mustard
- 9/2020 – String trimmed Japanese stiltgrass

Project Outcomes

Upon completion, the project treated a total of 3.2 acres: 2.6 acres of forest and 0.6 acres of meadow.

The project manager has evaluated the restoration work according the SER recovery scale. Significant improvements have been made but continued maintenance will be required to move the system closer to reference community conditions. A narrative assessment was done, rather than using the SER quantitative "Five Star System":

- Absence of threats:
    - ***Contamination***: The northeastern portion of the park was historically used as an orchard in the 1930s. Due to high levels of arsenic in pesticides used at the time, arsenic contamination was suspected. However, a soil test showed normal levels of arsenic. No action was required to remedy contamination
    - Over-utilization: At the start of the project, there was little evidence of over-utilization within park natural areas. As of 2020, there has been no apparent change in utilization levels.
    - ***Invasive species***: Cover of invasive species throughout restoration units is now less than 5%. However, degrading drivers such as excessive white-tailed deer browse, stormwater drainage, and yard waste dumping remain a problem. Continued management is needed to keep invasive species in check.
- Physical conditions:
    - Water chemo-physical: Excessive stormwater drainage from adjacent developed areas. Although water tests were not conducted, it is plausible that stormwater carries chemical contaminants into the park.
    - ***Substrate physical***: Erosion was not addressed within the stormwater drainage south of Unit 8; this would require large-scale engineering solutions. Soil erosion was addressed with small-scale erosion control structures within the forested drainage in Unit 7, which appear to be slowing erosion and encouraging deposition.
    - Substrate chemical: Soil pH was elevated above reference community levels, possibly as a legacy of agricultural use. Although pH levels were elevated, they may still be within the range of natural variability. No action was taken.

After several heavy rainstorms, the Zuni Bowl has filled with sediment and presumably stabilized the headcut. Despite being filled with sediment, the structure still functions to disperse stormwater energy and reduce erosion. Ideally, plant roots will begin to colonize stable areas of deposition.

- Species composition:
  - ***Desirable plants***: Relative to the start of the project, restoration units have dramatically increased native plant diversity. Increases in diversity are primarily within the shrub and herbaceous layers. Although native diversity is increasing, some species are not strictly native to the target natural community; it is unclear if these species will persist long-term.
  - Desirable animals: Generalist wildlife species still abound within Fitzhugh Park. Although no data has been collected, it is possible that increased cover and diversity of native plants may boost health and diversity of wildlife populations, especially invertebrates that rely on a diverse assemblage of flowering plants.
  - ***No undesirable species***: Cover of invasive species throughout restoration units is now less than 5%. Seed sources of invasives within Fitzhugh Park are now dramatically less than at the start of the project.
- Structural diversity:
  - ***All vegetation levels***: Overall forest structural diversity has improved. The mid/understory and herbaceous layers now contain mostly native species. Much of the woody understory is composed of young canopy

    - trees, which will continue to grow and provide more structural diversity as the plantings mature.
    - All trophic levels: N/A
    - ***Spatial mosaic***: Restoration activities have added spatial diversity within the park. Open areas with high levels of sunlight, dense herbaceous layers, woody plantings, and young thickets of naturally regenerating trees now contribute to spatial diversity within the park.
- Ecosystem functionality:
    - Productivity/cycling: N/A
    - ***Habitat & interactions***: Habitat resources present prior to project implementation still exist. Additional habitat resources have been added in the form of native flowering plant diversity, more complex forest structure, and course woody debris.
    - ***Resilience/recruitment***: Natural tree regeneration is still suppressed by extreme levels of deer browse. However, less palatable species such as sycamore and tuliptree are regenerating in project areas due to more available sunlight. A new cohort of young oak trees is establishing but will require continued maintenance and protection from deer in order to reach maturity.
- External exchanges:
    - Habitat links: No physical linkages to nearby natural areas were developed. However, new habitats created within Fitzhugh, such as open meadows with dense herbaceous vegetation, may serve as a link or refuge for flying insects and other highly mobile species traveling between two natural areas.
    - Gene flows: Pollinators and wildlife attracted to diverse restoration plantings may encourage additional gene flow if they carry pollen and/or propagules between Fitzhugh and other natural areas.
    - Landcape flows: N/A

Lessons Learned

Implementation of this project involved a variety of restoration methods and project management skills. Lessons learned along the way will be useful for implementation of future projects:

1. Project specifications must be very clearly communicated to contractors: Several mistakes were made throughout project implementation due to poor communication between the project manager and contractors. Prior to implementation, **all** specifications must be clearly communicated to contractors, no matter how minor. During implementation, project manager should observe the contractors and

immediately correct any mistakes or misunderstandings to avoid major project setbacks.

2. Source of straw mulch for erosion control is important: Straw mulch was used for erosion control on bare mineral soil following fall seeding in Unit 4. The source of straw (crop species) was not confirmed prior to purchase. In Spring 2019, an extremely dense cover germinated along with seeded native species. The cover crop grew rapidly and suppressed establishment of natives. This plant was identified as perennial ryegrass (*Lolium perenne*) which undoubtedly came in with the straw mulch.

   The ryegrass had to be mowed every two weeks from April through July. Fortunately, frequent mowing prevented establishment of the ryegrass and it was no longer present in 2020. Without investment of significant time mowing the ryegrass, it would have likely established and resulted in total failure of the meadow seeding. If using straw mulch for erosion control, it is imperative to make sure the source is an annual crop, such as winter wheat.

3. Dormant seeding was very successful: Prior to the restoration project at Fitzhugh Park, HOLH restoration seedings have only been implemented in the growing season between May and July. In contrast, dormant seedings are implemented outside of the growing season, usually between late fall and late winter. The purpose of dormant seeding is to break seed dormancy of species that require cold stratification in order to germinate. Most native forb species require cold stratification, while most native warm season grass (NWSG) species do not. Scientific literature on the subject generally reports a trade-off between seeding times: growing season seeding will yield higher dominance of NWSG, while dormant season will yield higher forb diversity and lower dominance of NWSG.

   Dormant seeding was implemented for Units 1, 2, 4, and 8 in November 2018. Mineral soil was exposed and the top ½ inch was fluffed using a Harley rake. Seed was sown by hand using vermiculite as a carrier in Unit 4 and wood shavings in Units 1, 2, and 8. Seed mixes for all units contained many forb species requiring cold stratification, while only Unit 4 contained a significant component of NWSG.

   In Spring 2019, strong germination of native species was observed in all seeded units. As of 2020, approximately 25-30 species included in the seed mixes have established. At least 13 of these species require cold stratification and were observed germinating in Spring 2019, indicating that the fall seeding was successful in breaking seed dormancy. Additionally, Unit 4 displayed strong germination and establishment of NWSG species, despite May-July seedings being best for NWSG establishment. Fall seedings appears to be a good tool for improving diversity and establishment of native forbs.

A drawback of fall seeding is fact that there is a several-month gap between seeding and germination, and there is no living vegetation present to stabilize soils over the winter. There is added labor and materials cost to install erosion control measures. Erosion and seed washout may still occur if the site experience a heavy rainfall prior to seed germination.

Heavy invasion of porcelain berry (*Ampelopsis glandulosa*) and low native plant cover and diversity in Unit 4 prior to restoration treatments. Photo taken in 2017.

Diverse native grasses and forbs establishing in Unit 4 in Summer 2019. Seeding occurred in Fall 2018; dormant seeding allowed native forbs to break dormancy and germinate immediately in Spring 2019 and establish well.

4. Woody seeding was unsuccessful: Seed of many woody plant species native to Eastern deciduous forests have complex germination requirements, often requiring multiple cycles of cold stratification followed by warm stratification in order to break dormancy. There is little information in the literature regarding the success of direct-sowing seed of woody forest plants, and most attempts have been unsuccessful.

   Due to archaeological resources present in Unit 1, planting live plants was initially not an option. Instead, several species of woody shrubs were direct seeded with the hope that they would establish without the soil disturbance associated with planting. Mineral soil was exposed and fluffed using a Harley rake, and seeds were sown in November 2018. It was expected that germination would not be observed until at least Spring 2020, however no evidence of germination was observed throughout 2020. As of this writing, direct-seeding woody species does not seem to be a reliable restoration method.

5. Success of sowing artificially stratified seed was unclear: Artificial stratification is a method of breaking seed dormancy without sowing seed in the dormant season. Seed is mixed with a moist carrier such as vermiculite and kept in a refrigerator for 10-120 days, depending on the species. This process mimics a cold winter spent in

the soil, and breaks seed dormancy. The advantage is that artificially stratified seed can be sown in the growing season and will germinate immediately.

Artificially stratified seed was used in Unit 6. Seed was stratified in April 2018 by refrigerating a mixture of seed and moistened vermiculite in sealed plastic bags. Seed was hand sown in June 2018. Prior to seeding, mineral soil was exposed by string trimming existing vegetation and leaf blowing litter. Unfortunately, the site was scoured by stormwater from heavy rainfall and few species in the seed mix established. The effectiveness of this method is unclear, although we learned that seeded areas which receive stormwater flow should be protected with mulch until plants establish.

6. Effectiveness of deer deterrents: Browse pressure from white-tailed deer is extremely heavy in Fitzhugh Park. NRB staff observed white-tailed deer within the park nearly every site visit. The severity of the problem became clear while staging containerized plants for a planting the following day; NRB staff left for lunch after staging plants in the field, and upon returning 30 minutes later found that every single plant had been browsed. Multiple deer deterrents were used to protect restoration plantings including garlic sticks, deer deterrent spray (Plantskydd), plant cages, "Rigid Seedling Protector Tubes", and TubeX Shelterguard tree shelters. Success of the methods was mixed and is discussed below.

   Containerized plantings installed in November 2018 in Units 2 and 8 were initially protected only by garlic sticks and Plantskydd. These methods are not physical barriers, but instead deter deer through unpleasant tastes and scents. Initially, these methods seemed to work as there was almost no browse observed throughout the winter. However, by April 2019 all plants were severely browsed. These deterrents likely need to be reapplied often to maintain effectiveness and are possibly ineffective in areas of severe browse pressure. This method may be appropriate for small landscape plantings but is unreliable and too labor intensive to be useful for restoration plantings.

   Plant cages were constructed from 5'tall, welded wire fencing with 2"x4" mesh. Cages were placed over individual woody plants, or around clumps of herbaceous plantings in Units 2, 2S, and 8. Cages placed over individual woody plants were either 18" or 24" diameter, and cages around herbaceous clumps were 6'x6'. Cages placed around individual plants were somewhat effective at preventing browse, although growing tips that escaped the cage would be browsed. The large mesh size (2"x4") also allowed deer to browse plants through the cages; this problem was more pronounced in 18" diameter cages than the larger 24" diameter cages. Cages placed around clumps of herbaceous plantings seemed to be very effective; no browse was observed on these plantings. Overall, cages for individual plants are expensive and less effective than solid tree shelters. However, they can be used effectively on larger planting stock and do not block any light or airflow.

“Rigid Seedling Protector Tubes”, as they are sold on forestry-suppliers.com, are 5’ tall, 5” diameter flexible plastic mesh tubes. The advantage of these tubes is that they are very cheap and do not block sunlight or airflow. They were used to protect individual woody understory plantings in Unit 2S. These tubes were very difficult to install, as branches would get stuck in the mesh holes while installing the tube. Because of the small tube diameter and open-mesh design, growing tips would routinely escape the tube and be browsed. Overall, these tubes were not effective and are not recommended for future restoration plantings.

Mixed planting of containerized understory shrubs typically found in Piedmont Mesic Mixed Hardwood forests in Unit 2S. “Rigid Seedling Protector Tubes” were used and proved mostly ineffective at preventing deer browse. Survival of this planting was low, possibly due to excessive shade or poor-quality planting stock.

TubeX Shelterguard tree tubes incorporate a solid translucent plastic panel inside of a plastic mesh tube. The panel degrades over time, while the plastic mesh stays intact and provides long-term protection from buck rub. The plastic panel is almost entirely transparent, making it more practical than traditional TubeX solid tubes for low-light plantings. These tubes were used to protect Unit 1 understory plantings, installed in December 2020. As of this writing, data is not yet available on the effectiveness of these tubes.

Despite varying effectiveness of different deer deterrent options, it is clear that physical barriers are absolutely essential for restoration planting success. Selection of the appropriate deer deterrent seems to depend on the site conditions (low vs high light levels) and resources available.

7. Herbaceous understory planting was successful: One of the primary learning goals of this project was assessing the effectiveness of understory restoration plantings. Many forests throughout Fairfax County have intact tree canopies but lack native understory structure and diversity due to excessive deer browse and other degrading pressures. Understory restoration is needed for proper forest functioning and maintenance of biodiversity.

Newly planted "mother colony" of native sedges and forbs in Unit 2S. Survival of these plantings was excellent, with many planting producing seed the following season.

In May 2019, 300 native herbaceous plants were installed in Unit 2S. The planting stock size ranged from plug to quart, and the mix contained a variety of native sedge and forb species commonly found in forest understories. The plantings were arranged in twelve "mother colonies", each colony containing 25 plants in a 5'x5' block. Species were divided evenly among all colonies, and each colony was protected with a welded-wire cage. Plantings survived and established well in 2019 and grew vigorously throughout 2020 despite low light levels in the restoration unit. Some plants flowered and set seed in 2020, indicating high vigor and reproductive potential.

Mother colonies were used rather than dispersed plantings for several reasons: clumped planting are easier to protect from browse, deer-tolerant plants should provide some protection to adjacent deer-intolerant plants, aggregations of flowering plants are generally utilized more frequently by pollinators than individual plants, and colonies of plants may expand more readily than individual plants. As of 2020, it is unclear if these claims are supported by the results of the Fitzhugh herbaceous plantings, or if these plantings will reproduce and expand. Development of the plantings will continue to be monitored, but preliminary results indicate that planting containerized herbaceous stock is an effective method of restoring forest herbaceous cover and diversity.

8. <u>Success of woody understory planting is unclear</u>: Unlike the herbaceous understory plantings in Unit 2S, the success of woody understory plantings is less clear. In April 2019, 200 one gallon containerized woody plants were installed in Unit 2S and protected from deer browse using either Rigid Seedling Protector Tubes or welded wire cages. The planting contained 12 species of woody understory shrubs and small trees.

   The planting established poorly, with some species establishing better than others. For example, maple-leaf viburnum (*Viburnum acerifolium*) had very low survival, while spicebush (*Lindera benzoin*) seems to have established well. Reason for low survival is unclear and may be related to one of the following: small/poor quality planting stock, improper installation of plants, low light conditions, inadequate protection from deer browse, and/or a prolonged drought in Summer 2019. Plants that survived into 2020 have shown little evidence of growth, although it is possible that full establishment and growth make take years in a low-light environment.

   In December 2020, 400 bare-root trees and shrubs were installed in Unit 1 and protected with TubeX Shelterguard tubes. Light availability in Unit 1 is higher than Unit 2S, so this planting included a large proportion of upland oaks such as *Quercus rubra* and *Q. alba*. Data on survival and establishment for this planting is not yet available. As of this writing, is it unclear if planting containerized woody stock is an effective means of restoring understory structure and diversity.

9. <u>Large container plantings had high survival</u>: Two, three, and five-gallon containerized woody plantings were installed in Units 2 and 8 in November 2018. The plantings were initially protected from browse by garlic sticks and Plantskydd,

but these deterrents proved ineffective and plant cages were installed in June 2019. These plants established well with strong growth and over 90% survival by the end of 2020, despite being heavily browsed in April 2019.

Cost of labor and materials was far more expensive than a comparable bare root planting. Using large container stock may be an effective method for small restoration areas, but this method is likely infeasible at larger scales unless planting density is reduced and funding is set aside for maintenance of each planting. Units 2 and 8 also had far more available light than Unit 2S, so it is unclear if large planting stock would establish well in a low-light environment under an existing canopy.

10. <u>Small scale erosion control structures had mixed success</u>: Erosion control and stabilization of a migrating headcut was the primary restoration goal for Unit 7. This unit receives stormwater flow from adjacent residential areas, and ongoing erosion may eventually cause excessive downcutting and degradation of the existing Piedmont Mesic Mixed Forest. To slow erosion and promote establishment of woody plant roots to stabilize soil and sediments, four different methods were used: stone channel liners, one-rock dams, herbaceous plantings, and a Zuni bowl.

    Stone channel liners were installed in Fall 2017 on the upstream end of the drainage, where the gradient was steep and erosion had exposed a network of tree roots. Surge stone was installed among the exposed tree roots to stabilize the soil. This method proved to be mostly ineffective, as the stone liner did not appear to catch sediment and was washed out after a few heavy rainstorms.

    One-rock dams were installed in Fall 2017 at periodic intervals throughout the low-gradient portion of the drainage. These dams are meant to slow stormwater, preventing erosion and encouraging sediment deposition. Over time, spaces between the rocks should fill with sediment and plants may begin to grow into the dam and into the deposition upstream of the structure. The effectiveness of these structures in Unit 7 was mixed. They appear to be slowing water and encouraging sediment deposition upstream, but they also appear to be creating small headcuts directly downstream of each dam. The solution may be to install better rock “footers” downstream of the dams. Sediment has accumulated between the rocks of each dam, but plants have not established likely due to low light levels in the drainage.

    Quart-sized herbaceous plantings were installed in Fall 2017 directly downstream of each one-rock dam, with the intention of further slowing stormwater and encouraging sediment deposition. These plantings did not establish well and were almost immediately washed out by heavy rainfall. In retrospect, the plantings may have been effective if placed directly upstream of each dam, where water pools and sediment is deposited.

After several heavy rainstorms, the one-rock dam has partially filled with sediment and encouraged upstream sediment deposition. It is unclear if these are functioning as intended, since they appear to be scouring soil downstream.

A Zuni bowl was installed in Fall 2017 at the downstream end of the Unit 7 drainage, where a large headcut was developing. A zuni bowl is essentially a plunge-pool that dissipates energy of flowing water. The goal of the Zuni bowl was to stabilize the headcut, slow stormwater, and encourage sediment deposition. The structure was largely successful and appears to have stabilized the headcut and accumulated several inches of sediment. Further monitoring will be required to assess the long-term effectiveness of this structure.

Long-Term Management

The restored systems will require on-going management to control NNI, maintain desirable herbaceous cover, and continue to establish restoration plantings. It is recommended that management take place every 2-3 years at a minimum and an ecologist monitoring visit occur every 5 years at a minimum.

Long-term management of Unit 4 should include periodic mowing and herbicide application in order to maintain native herbaceous cover. Prescribed fire is an ideal tool for maintaining meadow habitat; fire discourages woody plants, recycles nutrient, reduces pest populations, eliminates thatch, and provides other benefits that mowing alone does not provide. However, fire is unlikely to be feasible at Fitzhugh Park due to proximity to residential areas. Mowing should be used instead of fire every 1-3 years to discourage woody encroachment. Mowing is best implemented in early spring prior to green-up; mowing can also be implemented in winter but eliminates winter habitat for wildlife. Mowing should be avoided May through late August to avoid disturbing breeding/nesting birds. Spot herbicide application should be used as needed to discourage NNI species not adequately managed by mowing; this should occur every 3-5 years or whenever NNI species appear to be encroaching

Long-term management of forest restoration plantings in Units 1, 2, 2S, 3, and 8 should include survival surveys, tree shelter maintenance, and spot herbicide application. Survival and establishment surveys are needed to ascertain long-term success of the project and should be implemented every 3-5 years. Tree shelter maintenance should occur annually, or as often as available resources will allow. When plantings are mature enough to withstand deer browse and buck rub, shelters should be removed from the site and recycled. Spot herbicide application should be used as needed to discourage NNI species; this should occur every 3-5 years at a minimum.

Oak restoration plantings in Unit 1 will eventually need to be released from the existing canopy. Scientific literature indicates that upland oaks establish well and even benefit from light to moderate shade but will stagnate and eventually die if not released from shade after establishment. Upland oak seedlings and saplings must be released from shade in order to recruit into the canopy. Survival and growth should be closely monitored, and oaks should be released upon attaining a minimum height of five feet. Release treatments may involve girdling or felling of existing overstory trees to provide the appropriate amount of light for oak recruitment. If the plantings survive and establish, they should grow large enough to be released within 5-10 years.

Mother colony herbaceous plantings in Unit 2S should be managed to encourage establishment and expansion of naturally regenerated native herbaceous plants. This can be achieved by lightly disturbing the soil within the mother colony annually to encourage seed germination. Once the mother colony is fully occupied by desirable native herbaceous plants, expansion of the colony can be encouraged by lightly disturbing surrounding soil. This is an unproven method, so results should be carefully tracked and reported.

Erosion control structures within Unit 7 should be maintained every 2-3 years. Effectiveness of the structures should continue to be evaluated; structures can be modified as needed. Refer to the text of Let the Water do the Work for information on construction and maintenance of these structures.

Funding

The project was paid for with proffer funds provided by VDOT in 2014 for construction of I-495 express lanes.