Herbivory Impact Assessments, Public Engagement, and Recommendations for Management and Monitoring of White-tailed Deer (*Odocoileus virginianus*) for Arlington County Parks and Recreation Natural Lands

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Submitted by

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Executive Summary

White-tailed deer (*Odocoileus virginianus*) are beneficial to forest ecosystems because they convert plant material into energy and nutrients and provide enjoyment for wildlife enthusiasts. However, overabundant deer populations cause dramatic changes to vegetation and ecosystems, threatening North America's biodiversity, economies, and human health. Overbrowsing by deer and associated impacts to forest health are well documented from large expanses to urban parks.

A recent deer population survey, along with anecdotal evidence noted by Arlington County Department of Parks and Recreation (DPR), suggested that some Arlington forested parklands were being challenged by overabundant deer. In response, DPR hired White Buffalo Inc. (WBI) in 2022 to collect and analyze white-tailed deer vegetation impact data within the County's natural lands. In addition, WBI reviewed DPR stewardship goals, recent literature on ecological carrying capacity in forested lands, and adjacent municipality deer management programs. WBI also assisted DPR with engaging the public regarding results from deer browse surveys and possible management tools. Finally, WBI provided specific deer management recommendations as described in this report.

During fall 2022, deer browse impacts were studied and set up for long-term monitoring within plots at several County parks with both natural land and potential deer impacts: Barcroft, Benjamin Banneker, Bluemont, Bluemont Junction, Bon Air, Donaldson Run, Glencarlyn, Gulf Branch, and Windy Run Parks. While not all Arlington parks have deer impacts, the aforementioned parks were those where deer had been seen during previous deer population surveys and also suitable for ten-tallest browse survey efforts. In all, 22 plot centers were established and 31 plant populations were sampled. These populations were comprised of 13 species, some of which were sampled at multiple sites. Overall, 88% of all stems examined across Arlington exhibited browse damage by deer. Deer impacts varied among parks, within parks, and among plant species. Highly impacted areas showed reduced stature of preferred plant species and/or browse damage to low-preference species. Moderate impact was prevalent, with fewer areas meeting the criteria for high and low impact. Four smaller parcels within the Arlington County Park system (Doctor's Run Park, Fort C.F. Smith Park, Fort Bennett Park, and Grandma's Creek) were also assessed for deer browsing impacts using methods similar to those used by neighboring Fairfax County. Using data collected from ten randomly selected study plots at each park, it was determined that all four parcels exhibited signs of overabundant deer browsing. Mean deer browse rates on native understory in the study plots were high, ranging from 83–92%. Existing native cover in the understory, a metric used to assess forest health, varied from 21% native cover at Grandma's Creek to 65% native cover at Fort Bennett Park, all falling below a recommended threshold.

DPR stewardship goals are conservation and preservation of existing natural resources in County-owned natural areas. Based on peer-reviewed research, ecological carrying capacity (i.e., the point at which damage to normally renewable native plant resources occurs) for forested lands is approximately 20 deer per square mile. Deer densities above this threshold begin to negatively impact forests via browsing, and this metric is often used in surrounding counties and National Parks with deer management programs located in the District of Columbia, Virginia, and Maryland. More relevant than estimates of deer density is measurable negative impact monitoring, and these entities have also implemented deer browse impact surveys to assess forest health, in some cases for decades. Integral to most of these efforts is education and the formation of deer management plans, along with consideration of nonlethal control methods such as the use of repellents and fencing. However, with high deer densities, most of these entities that have active deer management programs implemented lethal control measures such as hunting or sharpshooting. Some counties have had to change their ordinances to allow hunting.

Overall, the results from browse impact survey efforts presented here do not bode well for the future forest health of Arlington's parks. Moderate browsing was prevalent. Based on previous research, a moderate classification of browse impacts is commensurate with the threat of overbrowsing. If deer population trajectories are left unchecked, browse rates may become heavier in the future, requiring more invasive and expensive solutions. Primary stewardship goals for Arlington natural lands continue to be conservation and preservation of existing natural resources, with a special emphasis on Natural Resource Conservation Areas. Recent deer population and vegetation impact surveys demonstrate these goals are not being met. Without active deer management, ecological health of Arlington's natural areas will continue to degrade. Even with deer mitigation efforts, it may take years or more for plant recovery because of the legacy effects of deer overbrowsing.

In summer 2023, DPR and WBI engaged with the Arlington public. Most (55%) participants responding to an online feedback form supported the recommendation for Arlington to develop a deer management implementation strategy for County Parks. Responses to specific strategies varied, with 43% and 63% of respondents being supportive of sharpshooting and surgical sterilization, respectively. Thirty-four percent of respondents were supportive of public archery hunting where permissible.

Preservation of Arlington's natural resources will require an active deer management program to reduce deer browse pressure and concomitant long-term monitoring to ensure management goals are being met. We recommend sharpshooting to reduce deer numbers and associated impacts on Arlington County lands. If sharpshooting is not feasible for some Arlington parks, we recommend surgical sterilization or a hybrid approach using a combination of methods to reduce deer populations. For example, a proportion of deer may be initially sterilized, followed by sharpshooting on remaining animals that have not been sterilized. The remaining options are less optimal. Public archery hunting may be considered as a last option for some DPR lands where feasible. We also recommend a comprehensive monitoring program using additional long-term deer browse survey methodologies, deer population estimates, and deer-vehicle collision data collection that can be related to healthy forest regeneration on DPR lands.

Table of Contents

Introduction

Accelerated development, climate change, and introduced pests and diseases continue to challenge the health of temperate forests in eastern North America (Aukema et al. 2010, Liebhold et al. 2013). In addition, high white-tailed deer (*Odocoileus virginianus*) populations cause dramatic changes to vegetation and ecosystems, threatening North America's biodiversity, economies, and human health (Côté et al. 2004). Overbrowsing by deer and associated impacts to forest health is well documented from large expanses (McWilliams et al. 2018) to urban parks (Connors and Gianotti 2021). In addition, overabundant, white-tailed deer populations challenge urban communities who may lose tolerance for deer-vehicle collisions (Bissonette et al. 2008, Ng et al. 2008) and increased human disease risk (Raizman et al. 2013, Kilpatrick et al. 2014). While some urban residents continue to appreciate deer (Conover 1995), others may view these animals negatively (Leong 2009). Many communities continue to struggle with solutions to mitigate overabundant deer impacts (Sterba 2012).

Arlington County, a densely populated suburban area, is at the point of being “built out” with most of its land area covered by single family homes and businesses interspersed with wooded corridors. This fragmented suburban landscape provides excellent deer habitat and can be restrictive to the implementation of some deer management options. There are many stakeholders in Arlington, and with any group of people, values, beliefs, and opinions regarding deer management will vary, and conflict.

Until recently, only anecdotal data from Arlington County Department of Parks and Recreation (DPR) and regional natural resource professionals on Arlington deer populations were available. By 2007, deer were observed inhabiting almost every forested park in Arlington (Arlington County Parks and Recreation 2011), raising concerns by managers who desire populations below ecological carrying capacity. For this report, we define ecological carrying capacity as the point at which damage to normally renewable native plant resources occurs (Arlington County Parks and Recreation 2011). In 2021, Arlington County hired a consultant to perform a UAS (unmanned aerial system, “drone”) survey to establish baseline population data for white-tailed deer. Results from that study suggest that some of the areas surveyed in Arlington County had a deer density above healthy ecological carrying capacity, and the authors recommended more aggressive deer management in these areas (Steward Green™ 2021). However, sound deer management should primarily be based on negative deer impacts to DPR lands. To provide additional context for decision makers, DPR desired additional inquiry to assess browse impacts to flora in Arlington parks.

In 2022, DPR hired White Buffalo Inc. (WBI) to perform data collection and analysis to determine deer ecological impacts within DPR Natural Areas. Moreover, WBI developed recommended strategies for mitigating negative ecological impacts, sustaining a healthy deer population, and protecting forest habitat for all native flora and fauna, in addition to providing recommendations for long-term ecological monitoring. Finally, WBI supported Arlington County staff with all aspects of public engagement, including feedback from residents, stakeholders, and relevant agencies as part of the process. Work was divided into three phases: (1) data collection, review, and assessment; (2) strategy development and public engagement;

and (3) recommendations, future steps, and final public engagement. This final iteration of the report addresses all phases.

Arlington Natural Resource Stewardship Goals

Arlington County DPR established its Natural Resource Management plan in 2010, with the goal of monitoring and protecting the unique natural resources in Arlington County (Arlington County Parks and Recreation 2010). Integral to the management plan is a requirement to periodically survey flora and fauna, which helps inform managers with an assessment of habitat health. Moreover, this plan recommended the establishment of a new category of County-owned open space representing the best remaining natural resources (e.g., flora, fauna, soil, water), known as Natural Resource Conservation Areas (NRCAs). In these areas, contiguous forests or high-value plant communities would be afforded protection via objective-based management. Today, NRCAs are located within, or identified as, Arlington Forest, Barcroft, Donaldson Run, Fort C.F. Smith, Glencarlyn, Gulf Branch, and Windy Run Parks. Most of the NRCAs are comprised of mature hardwood forests with significant natural features, such as rare native plants, wetlands, seeps or springs, unique geological features, or other attributes. The main management objective within NRCAs is conservation and preservation of existing natural resources.

White-tailed deer are present in many Arlington County parklands, including NRCAs. Per *Wildlife of Arlington: A Natural Heritage Resource Inventory Technical Report*, from 2005–2007 deer were observed inhabiting almost all forested parks in Arlington, with some people observing herds up to a dozen deer in North Arlington (Arlington County Parks and Recreation 2011). Also noted were obvious signs of deer overbrowsing within some parks. Arlington County identified management opportunities that included a recommendation for establishing a Wildlife Control Plan to mitigate negative impacts from local generalist species, such as deer, with potential to increase to nuisance level status. DPR has management plans for individual NRCAs as they relate to deer per below. Except for Arlington Forest Park, all other NRCA lands have management recommendations to monitor deer populations and deer browsing in these areas. These recommendations serve the basis for our browse impact assessments in Arlington County natural lands and this report.

<u>Arlington Forest Park</u> is the smallest NRCA at approximately one acre. This park is characterized by dry oaks growing on poor soils with sparse to open groundcover. Although this upland community has become rare, the park provides poor browse for deer and, thus, currently remains a low priority for browse monitoring (A. Abugattas, DPR, personal communication). Arlington Forest Park is mowed annually and managed to retain its savannah qualities.

<u>Barcroft Park</u> (65 acres) includes 24 acres of delineated NRCA lands, generally south of the paved trail, comprised entirely of forest (mixed-growth, early mature aged). Barcroft Park is unique in that it is considered the most ecologically significant County-owned natural site, including a globally rare magnolia bog plant community (Arlington County Parks and Recreation 2010). The DPR management plan for Barcroft notes anecdotal evidence of deer browsing, in addition to documented browsing on restored plants, both of which suggest an artificially high deer population.

Donaldson Run Park (30.2 acres) is entirely comprised of NRCA and includes older growth mature hardwood forest and a stream valley. The DPR management plan for Donaldson Run recommends continued monitoring of local deer populations and impact on native flora through browse studies or other methodologies.

Fort C.F. Smith Park (19 acres) includes 4.4 acres of delineated NRCA lands comprised of mature forest. The DPR management plan for Fort C. F. Smith notes a high local population of deer based on visible, well-worn deer trails.

Glencarlyn Park is the largest Arlington County park at 97 acres, with 56 acres delineated as NRCA. The NRCA areas include mature-old age natural forests, unique water resources, and diverse native flora (273 species present). The DPR management plan for Glencarlyn does not mention deer observations or impacts but suggests monitoring herbivory and the resident deer population.

Gulf Branch Park (37.7 acres) includes 5.4 acres of delineated NRCA lands and is primarily mature, late-stage successional hardwood forest. The DPR management plan for Gulf Branch does not mention deer observations or impacts but suggests continued monitoring.

Windy Run Park (14.4 acres) includes 7.5 acres of delineated NRCA lands comprised of riparian forest in the northernmost parcel. The DPR management plan for Windy Run NRCA notes a high population of deer based on observed deer trails and an active browse line (defined below).

Ecological Carrying Capacity of Deer in Forested Lands

Deer convert plant material into energy and nutrients that benefit other animals (McShea 2012). However, it is well established in the scientific literature that high deer abundance can negatively impact plant communities and biodiversity (Tilghman 1989, deCalesta 1994, deCalesta and Stout 1997, Waller and Alverson 1997, Horsley et al. 2003, Rooney and Waller 2003, Côté et al. 2004), including those natural areas in or adjacent to urban landscapes (Hygnstrom et al. 2011, Blossey et al. 2019). We define ecological carrying capacity as the point at which damage to normally renewable native plant resources occurs (Arlington County Parks and Recreation 2011). Deer herbivory at deer numbers exceeding ecological carrying capacity can result in the depletion of vegetation and forage (Côté et al. 2004). Both herbaceous and woody species are negatively impacted in areas of high deer populations. Unlike herbaceous species, most woody plants have the potential to escape threat once terminal shoots grow out of browse height (1.5–2 meters; Blossey et al. 2019). Those areas where plants cannot escape herbivory at these browsing heights will often form a visible "browse line" which is characterized as areas of no foliage, most conspicuous at the tree line edge (Curtis 2020). Across much of eastern North America, however, deer densities prevent transition from seedlings (<1 year old; up to 20 cm tall) to saplings (Kelly 2019, Long et al. 2012, Miller and McGill 2019). In addition to overbrowsing, shrubs, saplings, and small trees are debarked by male deer rubbing them with their antlers during breeding months, causing economic damage to nurseries, and in severe cases, killing trees (Nielsen et al. 1982).

In addition to negatively impacting tree regeneration, high deer browse pressure creates less diverse forests (Côté et al. 2004), and limited reforestation may further impede climate change mitigation efforts (Bastin et al. 2019). Although there are many drivers for forest degradation, at present, deer populations have been reported to be among the most important factors affecting forest regeneration in North America (Blossey et al. 2019). Deer also affect other species. For example, high deer populations have been associated with a decline in macrolepidoptera species (i.e., butterflies and larger moths) that specialize on understory plant species (Schweitzer et al. 2014), and elsewhere, aboveground insect abundance, richness, and diversity were higher where deer had been excluded for decades (Chips et al. 2015). A recent meta-analysis showed that overabundant deer populations consistently decreased average population abundance and species richness of forest birds (Crystal-Ornelas et al. 2021). Deer also facilitate the spread of invasive plants (Eschtruth and Battles 2009).

Urban and suburban areas offer refuge for growing deer populations, putting parks and natural lands within these landscapes at risk. These areas offer safety because there is often no public deer hunting in these areas along with few natural predators (Swihart et al. 1995, Etter et al. 2002). While coyotes and deer may overlap in these areas (Morey et al. 2007), predation is often not enough to curb deer population growth (Bragina et al. 2019). Moreover, these areas offer shelter via greenspaces (Kilpatrick et al. 2011) and supplemental food via gardens and ornamental plants (DeNicola 2000). Deer can reach high abundances in urban landscapes despite challenges from traffic and pollution from light, noise, and chemicals (DeNicola 2000, Ditchkoff et al. 2006). One study suggests that urbanization did not correlate with deer stress levels (Potratz et al. 2019). High quality habitat and food resources, as well as high deer survival rates, allow for rapid population growth, with herd size potentially doubling every 2–3 years in urban, suburban, and exurban landscapes (Curtis 2020). These populations and resulting impacts on vegetation, regeneration, and understory have caused some park systems to monitor and manage deer.

Deer must be managed at or below ecological carrying capacity to prevent depletion of resources. Although deer densities in many areas of the eastern United States may exceed 100 deer per square mile (Porter 1991), forest regeneration is negatively impacted when deer population densities generally surpass 20 deer per square mile (Drake et al. 2002, Horsley et al. 2003). Others have recommended densities less than 16 deer per square mile (Waller and Alverson 1997). Abella et al. (2022) found that after culling reduced deer abundance by half (from 44 to 22 deer per square mile), browsing on tree seedlings was reduced to a point where most seedlings grew without damage.

Arlington County contracted with Steward Green™ in 2021 to conduct an aerial deer population estimate using UAS technology. In that survey, researchers confirmed at least 290 deer on lands that could be surveyed in Arlington (e.g., Federal lands were excluded), or an average of 13 deer per square mile. However, by region in areas with forest or stream corridors, densities were higher, ranging from 20–39 deer per square mile. Steward Green™ (2021) noted that challenges related to their efforts to collect data during daytime hours likely produced underestimates, suggesting that Arlington County has more deer than estimated. This is not surprising, given that some deer population estimates, including aerial efforts, may underestimate actual deer densities (Forsyth et al. 2022). Moreover, we note that approximately 42% of Arlington land is comprised of impervious surface (e.g., roads, sidewalks, buildings; Arlington County Sustainability and

Environment 2023), so the actual area where deer may exist may be home to higher deer densities. In sum, actual densities of deer within DPR parks specifically are likely much higher when considering the number of deer counted during the Steward Green™ (2021) aerial drone survey within each park boundary.

While population estimates are a valuable tool to provide supplemental data and benchmarks for general carrying capacity goals, this metric alone is unlikely to be a sufficient predictor of deer impacts (Putman et al. 2011). Therefore, managers should focus on assessing actual deer impacts such as overbrowsing on flora, or in combination with population estimates (Boulanger et al. 2014). Rawinski (2014) provided the following guidance when assessing deer impacts:

- While deer are generalist herbivores, they nevertheless show distinct preferences for some plant species over others. Plants can be classified as either preferred/staple or low-preference/avoided.
- Deer diets and deer movement patterns change seasonally. Browse pressure on low-preference species increases with decreased availability of preferred species.
- Damage from deer browsing can be easily distinguished from damage caused by insects or rabbits.
- Deer impacts are never uniform across a landscape. In any park or natural area, the levels of browse impact will vary. Deer tend to avoid feeding near frightening features of their environment. Fenced areas and places inaccessible to deer can reveal important insights about deer impact.
- While it is difficult to say that deer browsing caused the extirpation of certain plant species, the larger point is that the functional role of plants in the ecosystem can be compromised.
- Time must also be considered. A forest may show legacy effects from periods of high or low browsing pressure.

Researchers have described browsing damage intensity in the literature. For example, McWilliams et al. (2018) described browsing as deer's consumption of twigs, leaves of trees or shrubs, or tender shoots with the following levels of intensity:

> **Low:** Plot is inside a well-maintained fence or minimal browsing is observed, or vigorous seedlings are present and of varied height if no well-maintained fence is present. Herbaceous plants are present and are able to complete their life cycles.
>
> **Moderate:** Evidence of browsing is observed but not common. Seedlings are common but with limited variability in height. Stump sprouts are heavily browsed or not present. Herbaceous plants show a lack of or inhibited flowering and fruiting. There is little or no evidence of browsing on nonpreferred plants.
>
> **High:** Evidence of browsing is common on preferred vegetation. Preferred seedlings and herbaceous plants are rare or absent. Nonpreferred plants show some evidence of browsing. Browse-resistant vegetation is limited in height growth. Evidence of browsing is everywhere. Nonpreferred, browse-resistant plants show signs of heavy repeated browsing, and a browse line is present.

Moreover, Pierson and deCalesta (2015) described browsing of seedling intensity below. Note that “hedging” refers to height suppression related to repeated deer browsing—hedged plants are stunted in height, and stems are browsed back to short, thick stubs.

> **Zero-light impact** (<50% of stems browsed) represented minimal deer impact on seedlings that would not result in reduced recruitment of seedlings into the sapling class.
>
> **Moderate impact** (>50% of stems browsed but seedling not hedged) represented deer impact that should result in recruitment of less preferred deer seedlings and may result in reduction in recruitment of preferred forage seedlings.
>
> **Heavy-severe impact** (>50% of seedling twigs are browsed and stunted by hedging) represented repetitive and destructive deer browsing that would prevent seedlings from growing into sapling-sized seedlings.

In general, impacts of at least “moderate” intensity require consideration of management intervention (McWilliams et al. 2018). If deer population trajectories are left unchecked, browse rates may become heavier in the future, requiring more invasive and expensive solutions.

Deer Management in Surrounding Communities and Parklands

Provided here is a partial review of deer management programs implemented by surrounding communities and parks in Washington, D.C., Virginia, and Maryland. These areas were selected based on their proximity to Arlington County and because of their similar landscape configurations in some areas, with forested lands within or adjacent to urban/suburban communities. Also included is information on task groups and timelines to inform Arlington of previous collaborations that eventually led to deer impact mitigation efforts. Integral to most efforts listed below is the implementation of public education in forming deer management plans, along with consideration of nonlethal methods such as the use of repellents and fencing. However, these jurisdictions have also implemented common lethal deer population control efforts such as hunting programs and sharpshooting. Although managed hunting has been used to reduce deer populations in suburban landscapes, the notion that hunting alone may reduce deer densities to allow for forest regeneration has been challenged (Williams et al. 2013, Blossey et al. 2019). Arlington County, in addition to the Cities of Alexandria, Falls Church, and Fairfax, are unique within the area given they currently are not managing deer (Fig. 1).

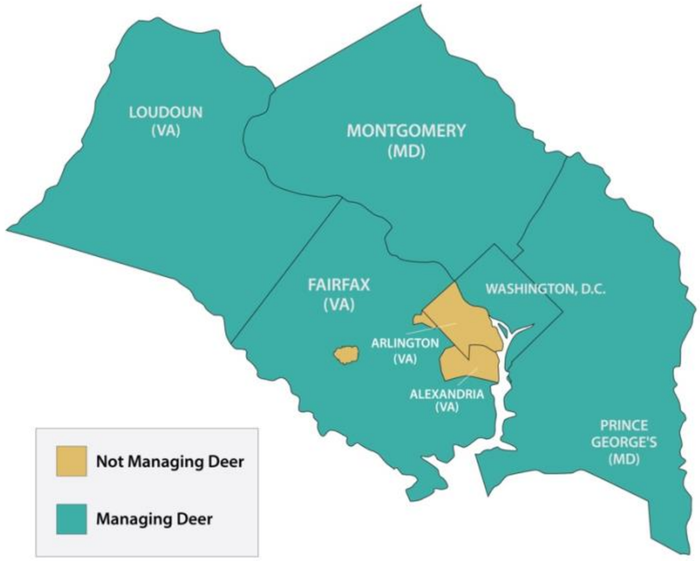

Figure 1. Arlington County as it relates to current deer management in surrounding jurisdictions.

Washington, D.C.

Rock Creek Park (RCP), part of the National Park Service (NPS), is located within the northwest and northeast quadrants of the District of Columbia. The park consists of 99 units, the largest and most natural of which is 1,754 acres. The park is surrounded by residential and commercial areas of Washington, D.C. and Maryland (National Park Service 2022). Historically, deer were uncommon and tracked by observation cards until 1990, when managers began having concerns over the negative effects of deer overabundance and started to collect data to document deer densities and vegetation health. NPS had started recording demographic data on road killed deer in RCP in 1989. In 1990 NPS established 27 long-term vegetation plots (20 x 20 meters) in RCP that have documented decreasing shrub cover and tree seedling densities (Hatfield 2005). In 1995, NPS created an advisory Science Team, comprised of subject matter experts to guide data collection and analysis of deer densities and effects. Various deer monitoring studies have been conducted, including spotlight surveys (1996–present), aerial forward looking infrared surveys (FLIR,1997–1999), radio telemetry (2001–2008), and distance sampling (2000–present; National Park Service 2011). Annual distance sampling continues to provide quantitative estimates of deer densities for RCP, which peaked in 2010 at 100 deer per square mile (National Park Service 2022). Annual spotlight surveys along a 22-mile route provides an assessment of population densities through time.

In 2000, NPS established a deer exclusion study, involving 20-paired unfenced and fenced plots (1 x 4 meters), in RCP to directly study the effects of deer on vegetation and forest health. Analysis of deer exclusion data from 2001–2004 documented an average 2 to 3 times lower percent cover of herbaceous and woody plants in unfenced plots compared to fenced plots (Rossell et al. 2007). A subsequent report summarizing deer exclosure data from 2001–2014 found similar results in percent plant cover; paired fenced plots also had on average 50% higher species richness of woody and native plants, significantly higher vegetation thickness, and significantly more tree seedlings in the 25–50 cm class (Krafft and Hatfield 2011, 2015). Based on these results from the controlled deer exclusion experiment, NPS concluded that impacts observed in open plots are "…directly attributed to deer browsing and indicate deer are affecting the integrity of the understory structure and species composition, diminishing the value of habitat for other wildlife." (National Park Service 2011).

NPS initiated development of a white-tailed deer management plan in 2005, the final version of which was published in 2011. A 3-day internal scoping meeting outlined purpose, priorities, actions and responsibilities with NPS employees. Public scoping occurred over 4 months in 2006, including 2 public meetings to solicit comments and concerns. By 2009, a draft *Rock Creek Park White-tailed Deer Management Plan/Environmental Impact Statement*, outlining four possible management action plans, was made public and open for comment between July and October, with one public meeting offered in September. NPS released the *Final Rock Creek Park White-Tailed Deer Management Plan/EIS* in 2011. The final plan outlined four possible actions: A) status quo or "no action", where the park maintains its monitoring and research as well as use of fencing and repellents to protect native species and small natural areas; B) status quo + non-lethal control with large-scale (>5 acres) exclosures and reproductive control of does (i.e., sterilization and acceptable contraception); C) status quo + lethal control (i.e., sharpshooting and capture and euthanasia); and D) status quo + combined lethal and non-lethal control. Public hunting was not proposed as a lethal control option because hunting is not allowed in National Parks. The plan recommended option D. The plan also identified two thresholds for action: 1) a target deer density within RCP at 15–20 deer per square mile, based on previous study in similar regions, and 2) a minimum seedling density of 51 seedlings per plot within 67% of unfenced long-term plots.

In May 2012, NPS adopted deer management option D for RCP, with continued use of existing non-lethal control measures, such as protecting sensitive plants and small areas with fencing and deer repellents, and lethal control measures to reduce deer populations (National Park Service 2012). In 2012, active deer management with lethal control began in RCP, starting with 20 deer culled by park managers (Parsons et al. 2017). A larger USDA sharpshooting operation began in 2013 and continues today. Meat is donated and tree seedling density tripled due to the culling program (National Park Service 2022).

Other Washington, D.C. NPS Parks: In 2022, NPS finalized a public process to create a plan for National Capital Parks – East, which calls for reducing the deer populations to "*protect and restore native plants and promote healthy and diverse forests"* (National Park Service 2024). These parks include Anacostia Park, Kenilworth Park and Aquatic Gardens, Fort Mahan, Fort Dupont, Fort Davis, Fort Chaplin, Fort Stanton, Fort Ricketts, Fort Greble, Battery Carroll, and Shepherd Parkway. The proposed action for this environmental assessment and preferred alternative is lethal control via professional sharpshooting (National Park Service 2021).

Virginia

Fairfax County has a Deer Management Program that manages white-tailed deer populations on public parklands to address safety and health concerns, as well as ecological damage by deer overabundance. Growing resident concerns over negative effects of increasing deer densities and a fatal deer-vehicle collision in 1997 prompted the County to create the Fairfax County Deer Management program in 1998. The program is implemented by the Fairfax County Police Department (FCPD), the Fairfax County Park Authority (FCPA), the Northern Virginia Regional Park Authority (now NOVA Parks), and other public landholders (e.g., Bureau of Land Management and The Nature Conservancy). Before implementation of the Fairfax County Deer Management Program, Virginia Department of Game and Inland Fisheries (currently Virginia Department of Wildlife Resources, or DWR) estimated deer densities in Fairfax County parks that ranged from 90–419 deer per square mile (Fairfax County EQAC 2019). Once created, the Fairfax County Deer Management Program partners conducted their own deer density surveys: FCPA started spotlight surveys of deer densities in the late 1990s, while FCPD began regular monitoring with infrared camera surveys in 2000. In 2006, FCPA also adopted camera surveys at a smaller scale than FCPD (D. Lawlor, Fairfax County Park Authority, personal communication). In 2013–2014 FLIR surveys were also used to estimate deer populations across select County parks. The latest available estimates of deer densities from 2019 range from 40–100 deer per square mile (Fairfax County EQAC 2019). Initiated in 2010, FCPA started conducting deer browse impact surveys in earnest in 2016, based on Pierson and deCalesta (2015), across 556 permanent plots established throughout Fairfax County parks (Fairfax County EQAC 2019).

The Fairfax County Deer Management Program uses both non-lethal and lethal tools to manage deer. Non-lethal tools include exclosures, repellents, and habitat modification. By 1999, Fairfax County began sharpshooting deer to actively reduce their abundance in County parks. At present, the Fairfax County Deer Management program employs three lethal control strategies: 1) lottery archery hunting by vetted individuals, 2) lottery managed firearms hunting by vetted individuals, and 3) sharpshooting by FCPD. Archery was not used in earnest until 2010 and has since become the primary means of deer herd reduction in Fairfax County suburban parks. The archery program now includes >100 park parcels County-wide totaling approximately 21,500 acres. During the 2022–2023 deer season, archery was responsible for 94% of harvested deer with 521 volunteer hunters contributing 32,832 hours. Since 2015, archery harvests have ranged between 604 and 1,092 deer annually, with lower harvests in recent years as the deer population is gradually reduced over time. Between 1998 and 2023, 15,716 deer were harvested through the county program using all available methods (Fairfax County Deer Management Program 2023). Archery hunting in Fairfax County is recognized as one of the best statewide examples of a successfully run program of its kind (J. Green, Virginia Department of Wildlife Resources, personal communication). The program also maintains an exceptional safety record. In 2019, Fairfax County reviewed non-lethal control of deer densities, by sterilization or contraception, and concluded neither options were practical nor cost effective for free-ranging deer at a County-level scale (Fairfax County EQAC 2019).

The Fairfax County deer program references 15–20 deer per square mile as a healthy threshold of deer densities from published studies. To support the deer program with data, Fairfax County has conducted deer population surveys across the County each year at a few parks to collect baseline data. However, recent changes associated with the detection of chronic wasting disease (CWD) in Fairfax County and its inclusion in a CWD Disease Management Area will affect monitoring efforts going forward. With CWD now confirmed in the County, the DWR will no longer authorize the use of bait for camera surveys due to potential disease spread. As such, staff are investigating the use of alternative field methods to collect monitoring data on the deer herd.

Fairfax County excludes deer from restoration sites using electrical fence, double fences, welded wire fence, and tree protectors of various shapes, sizes and efficacy (D. Lawlor, Fairfax County Park Authority, personal communication). Recruitment projects in recent years have also been implemented to protect oak and other seedlings. These efforts included the use of welded wire fencing to create small circles of 5’ high fence about 3–6’ in diameter, anchored to the ground with small fence stakes and sod staples.

Fairfax County has tracked reportable deer-vehicle collisions in Fairfax County annually since 1998 via police reports through the Traffic Records Electronic Data System (TREDS). According to data from TREDS, an average of 102 reportable deer-vehicle collisions (DVCs) have occurred annually in Fairfax County since 2010, ranging between 75–120 DVCs a year during that time frame. Although numbers have fluctuated over the years, Fairfax County has seen a declining trend overall in reportable DVCs County-wide (K. Edwards, Fairfax County Police Department, personal communication). These numbers have decreased and remained lower after the addition of the archery program for deer management and during a period of significant human population growth in the County overall.

In sum, population surveys, harvest records, browse surveys, and deer-vehicle collision data all support Fairfax County deer program effectiveness. Archery hunting, managed firearm hunts, and sharpshooting are working to reduce and stabilize the deer population and negative associated impacts in Fairfax County. Moreover, deer management efforts have enabled Fairfax County to monitor deer herd health and conduct surveillance for CWD through testing of harvested deer. Since FY 2020, over 1,240 deer harvested through the Fairfax County Deer Management Program have been tested for CWD. Over 82% of the samples submitted for testing were from hunter-harvested deer in the County’s archery program. Fairfax County deer management efforts also help address food insecurity by providing locally sourced venison for food to individuals and families through local processors and charitable organizations (K. Edwards, Fairfax County Police Department, personal communication).

City of Fairfax initiated a multi-year, experimental surgical sterilization study within city limits in 2014 (DeNicola and DeNicola 2021). The study was approved by DWR to provide insight into the cost and effectiveness of sterilizing female deer in an urban/suburban context. White Buffalo Inc. implemented sterilization efforts from 2014 to 2018, which involved coordinating with local police, training volunteer veterinarians, and camera surveys to provide estimates of deer population size. In total, 51 female deer were sterilized. Population estimates from this study demonstrated a decrease from 91 deer (5.5 deer per square kilometer [~14 deer per square mile]) in 2014 to 40 deer in 2018 (2.4 deer per square kilometer [~6 deer per square mile]; DeNicola and DeNicola 2021). However, part of the reduction (49%) in deer was due to dispersal and mortality, with 25 of the female deer either dead or dispersed by the end of the study. In sum, it is important to note that the reduction of deer did not occur by sterilization alone. The cost per deer sterilized in Year 1 of the Fairfax City study was $2,331 (DeNicola and DeNicola 2021). This study was only approved by DWR for a 5-year period for scientific research; there are currently no surgical sterilization programs in effect in Virginia. There have not been any further population surveys to determine long-term impacts of the study FCPD (D. Lawlor, Fairfax County Park Authority, personal communication).

Prince William County Supervisors approved an ordinance change in 2015, allowing archery hunting from 100 yards to 100 feet from regularly occupied structures. With the cooperation of representatives from the Prince William County Police Department, Public Works, Parks and Recreation, and the Virginia DWR, a pilot archery deer management program commenced in 2017 on public parklands (Briscoe 2019). As of this writing, however, this deer management program is on hold until support staff are made available to run it.

Within Prince William County, **NPS Manassas National Battlefield Park** preserves over 5,000 acres of Virginia countryside to conserve the cultural and natural features of the landscape as they were during the civil war. Long term monitoring in the park demonstrated consistently high deer densities and negative effects on park vegetation. Between 2001 and 2013, deer densities averaged 139 deer per square mile. Historic orchards and crops were being overbrowsed by deer. The park used long-term, open vegetation plots established in 1990 by NPS and a deer browse survey established in 2000 to analyze deer impacts on natural habitats. The deer browse survey consisted of 10 paired unfenced and fenced plots (2 x 6 meter) randomly placed across three dominant forest types. Plant cover, vegetation thickness, and survival rates of tree seedlings were recorded annually (National Park Service 2014a). By 2004, all plant measures were lower in open than fenced plots, indicating deer were having negative effects on forest habitat and regeneration (Gorsira et al. 2006). When deer browse plots were resurveyed in 2009, tree seedling survival was 23% in fenced plots and 0% in open plots (McShea et al. 2010).

In 2010, NPS initiated the development of a management plan for Manassas National Battlefield, Antietam National Battlefield, and Monocacy National Battlefield Parks, with an internal scoping meeting in 2010 and creation of an advisory Science Team. Between March and September 2011, public scoping included three public meetings. In 2013, a draft management plan was released, and a 60-day public comment period included three additional public meetings. In 2014, the *Final White-tailed Deer Management Plan and Environmental Impact Statement: Antietam National Battlefield, Monocacy National Battlefield, and Manassas National Battlefield Park, Maryland and Virginia* was published. This plan was an adaptation of the aforementioned *Rock Creek White-tailed Deer Management Plan*. The plan acknowledged a need to reduce deer densities to preserve park natural and cultural resources, and outlined four alternative action plans similar to those proposed for Rock Creek Park: A) no additional action with current management continuing, including deer and vegetation monitoring, data management, research, and select use of fencing and repellents; B) use non-lethal tools to protect park resources, including construction of large-scale exclosures to allow forest regeneration and use of nonsurgical reproductive control; C) reduce deer numbers directly by lethal means, primarily sharpshooting, and include protective methods from alternative B, such as fencing and deer-resistant crops; D) combine alternatives B and C to allow for reduction of deer densities by lethal means to manage deer populations with appropriate non-lethal methods, including nonsurgical reproductive control, and lethal methods. The plan recommended alternative D, which was adopted by the park (National Park Service 2014b). As with other National Parks researched for this review, public hunting was not permitted and was, therefore, not a lethal control measure considered by the plan.

In 2019, the park's first culling operation was implemented by sharpshooters from the USDA, and all meat was donated to a food bank (National Park Service 2018a). Manassas National

Battlefield Park's deer management plan seeks to reduce the following: deer-vehicle collisions, deer densities, Lyme disease, and tree seedling mortality within open plots. The park's deer density target is 15–20 deer per square mile. Continued vegetation monitoring will be used to document whether reductions in deer densities result in reduction of deer browsing and increased forest regeneration (National Park Service 2014a).

Maryland

Howard County has over 20,000 acres in parkland and open space, as well as 17,500 acres of farmland in preservation easements (Howard County Deer Task Force 1999). In 1996, the Howard County Deer Task Force (HCDTF) was created in response to growing resident concerns over increasing deer numbers. The HCDTF was comprised of residents and representatives from the Howard County Farm Bureau, MDNR, Howard County Department of Recreation & Parks, Howard County Cooperative Extension, Animal Advocates of Howard County, Wild Bird Centers of America, Washington Suburban Sanitary Commission, Cider Mill Farm, and Howard County Police Department Animal Control Division. The HCDTF was charged with assessing human-deer conflicts and outlining deer management options. To prepare their recommendations, the task force administered a mailed deer survey in 1998 to 7,700 Howard County property owners. FLIR surveys of Howard County Parks in 1998 established deer densities between 47–118 deer per square mile. A vegetation survey at the Middle Patuxent Environmental Area (MPEA), the largest of Howard County parks, in 1998 demonstrated that the park had large trees but little understory, including tree seedlings. In 1999, ten paired unfenced and fenced deer exclosure plots (20 x 20 meters) were established at the MPEA and surveyed again in 2003 and 2007. By the end of the study, plant richness was higher within fenced plots, as was understory plant cover and stem height. Invasive plants were more prevalent in open plots revealing potential facilitation of plant invasions by deer (Duguay and Farfaras 2011). HCDTF also reviewed deer management efforts modeled within the state and County and listened to presentations by local experts. Completed in 1999, *The Howard County Deer Task Force Report* identified the County's primary deer-human conflicts, including 1) damage to crops and homeowner plants, 2) deer-vehicle collisions, 3) ecological damage, and 4) deer-related diseases. The report discussed a comprehensive list of alternative methods to reduce human-deer conflicts and emphasized the importance of public education to reduce these conflicts.

As recommended by the HCDTF, a Deer Project Manager position was created to serve as a point of contact for the public and liaison with the multiple entities involved in deer management. The Deer Project Manager also collects data, produces outreach materials, and develops management strategies (Howard County Department of Recreation & Parks 2002). A multi-agency Work Group was also formed to implement a deer management program for Howard County. In 2002, the *Howard County Department of Recreation and Parks Comprehensive Deer Management Plan* was released. The plan's goals are to reduce human-deer conflicts, protect natural areas, and maintain a healthy deer herd. To do so, the plan called for collection and centralization of data on deer populations, deer-vehicle collisions, damage to crops and gardens, as well as ecological damage. The same lethal and non-lethal methods for reducing negative effects of deer presented in the *Howard County Deer Task Force Report* were discussed with one additional alternative: habitat management. In the plan, herd size reduction by lethal means was one of the only viable management tools available to the Department of

Recreation & Parks to reduce ecological damage by deer. The use of humane and safe methods to manage deer is repeatedly emphasized throughout the document.

Lethal control, in the form of managed hunts, began in Howard County parks in 1998 and continues today. In the 2022/2023 hunting season, shotgun and/or archery hunting was allowed at eight parks. Sharpshooting is also used within select parks with meat donated to local food banks. Public education and outreach materials are also important aspects of the Howard County deer management program (Howard County Department of Parks & Recreation 2002).

Howard County's deer management plan recommends identifying thresholds for action based on negative impacts of deer, for example number of resident complaints or number of deer-vehicle collisions, rather than a predetermined deer density (Howard County Department of Parks & Recreation 2002). The Deer Management Program states that reduced impacts on natural vegetation has been documented in parks that are actively managed to reduce deer numbers (Howard County Department of Recreation & Parks 2019).

Montgomery and Prince George's Counties

The Maryland-National Capital Park and Planning Commission (M-NCPPC), established in 1927, provides long-term planning and land acquisition for public parks in Montgomery and Prince George's Counties, MD. Montgomery County shares a border with Rock Creek Park and has been actively managing deer since 1995. Prince George County also has an active deer management program. Although both Montgomery Parks and Prince George's County Parks & Recreation are under the umbrella of the M-NCPPC, the departments (including deer and wildlife management) are run separately from one another, per below.

In **Montgomery County**, the M-NCPPC (Montgomery Parks) manages 37,768 acres of parkland across 419 parks and open spaces. Responding to citizen concerns about deer-related problems, the Montgomery County Council established a Deer Task Force in 1993 to assess human-deer conflicts in the County and make recommendations on steps forward (Montgomery County 2022). As a result of the task force's recommendations, the Montgomery County Deer Management Work Group (DMWG) was established in 1994 to develop a deer management plan and oversee the implementation of a County-wide deer management program (National Park Service 2011). The original DMWG was comprised of representatives from M-NCPPC Department of Parks, Maryland Department of Natural Resources (MDNR), Montgomery County Police Department, U.S. Geological Survey Biological Services, and Montgomery County Cooperative Extension Service (Montgomery County Deer Management Work Group 1995). Today, the DMWG also includes the Montgomery Soil Conservation District, the Montgomery County Police Department, the U.S. National Park Service, the City of Rockville, and the Washington Suburban Sanitary Commission (Montgomery County 2022). In 1995 (and updated in 2004), the DMWG published the *Comprehensive Management Plan for White-tailed Deer in Montgomery County, Maryland: Goals, Objectives, Implementation*. The plan focused on reducing human-deer conflicts, specifically deer-vehicle collisions, crop and ornamental plant damage, and degradation of natural areas. Given the variation in types and degree of deer-human conflicts across the County, the plan acknowledges that a single management approach is not appropriate and, therefore, provides multiple deer management options, with the M-NCPPC having the authority to determine which management tool to use. Public meetings were held in fall 1995 to educate residents about deer impacts and to solicit input on management actions appropriate for the County.

To assess negative effects of deer, Montgomery County has collected data since 1990. Data collected include deer-vehicle collisions, incorporated into a Geographic Information System (GIS) to identify hotspots; depredation to agricultural crops and plants on residential properties; and vegetation monitoring in park natural areas. The Montgomery County Office of Agriculture administered a Deer Damage Survey to growers in 2004 and 2014, documenting significant losses to crop production due to deer browsing. Following vegetation surveys in open plots that documented forest degradation, a deer exclosure study was initiated, in 1990, using paired unfenced and fenced plots (20 x 20 meters) in all parks. By 1992, an average loss of 65% of species richness was attributed to deer browsing. A qualitative study from 1995 and 2001 using these deer exclosures documented decreased plant height, understory density, as well as counts and species diversity of seedlings in open plots compared to exclosures; these effects were greatest in parks with a higher density of deer (National Park Service 2011).

Montgomery Parks have two park facilities that are high fenced: Brookside Botanical Gardens and the Pope Farm Nursery. They also use fencing around select, small, rare, threatened, and endangered (RTE) plant communities and individually with reforestation tree plantings. Select facilities may use, or have used, repellents, but they do not employ their use at a comprehensive application level (R. Butler, Montgomery Parks, personal communication).

By 1996, M-NCPPC Montgomery Parks started using lethal control in the form of managed public deer hunts and sharpshooting by County park police (National Park Service 2011), with hunting becoming the primary tool used to reduce deer numbers on public and private lands (Montgomery County Deer Management Work Group 2015). Three hunting programs are in use today: 1) Lottery Managed Deer Hunting, with shotgun and archery; 2) Cooperative Managed Hunting, involving pre-selected, experienced and insured hunting groups; and 3) Tenant Managed Deer Hunting, by qualified hunters on agriculturally leased lands to mitigate crop damage. By 2015, select urban areas were open to managed archery hunting. Sharpshooting began at a program level in 2001, continues to be used annually, and harvested meat is donated to the Capital Area Food Bank, nearly 385,000 pounds to date. Montgomery Parks lethal deer population management programming now includes 70 park units and approximately 22,000 of the available 37,768 acres of M-NCPPC parkland. Overall, M-NCPPC Montgomery Parks land comprises approximately 11% of the total land area of the County. The working group’s 2015 annual report stated that deer populations had decreased on average 59% in managed areas and that deer-vehicle collisions had decreased near managed areas but not County-wide.

The plan does not provide deer density thresholds for action because impacts of a given deer density differ depending on local context. Rather, the plan recommends using subjective thresholds of negative effects, such as number of deer-vehicle collisions or number of deer damage complaints to determine when management actions are applied (Montgomery County Deer Management Work Group 1995). Montgomery Parks monitors managed hunting and sharpshooting harvest number trends and harvest rate trends toward management action or level of effort decisions on a location-by-location basis. In most managed parks, trends in both harvest numbers and harvest rate (per unit effort of time) show decline and stabilization, an indicator of success in localized population reduction. Analysis of reported DVC's occurring within ¼ mile of parkland also demonstrate substantially lower percentages of accidents within ¼ mile of parks under population management vs. those occurring within ¼ mile of parks not under management (R. Butler, Montgomery Parks, personal communication).

In Montgomery County, the **City of Rockville** has ~1,035 acres of parkland spread across 65 parks (City of Rockville 2021). Rockville developed its first policy regarding white-tailed deer in 1995, *Rockville's White-Tailed Deer Control Policy*, in response to resident concerns over increasing deer numbers and impacts on landscaping and gardens. Deer were considered a nuisance rather than a problem; it focused on data collection, resident education, and analyzing resident complaints. Population management and lethal reductions were only to be considered if non-lethal methods had failed. By 2009, concerns over deer overabundance had increased enough for the Mayor and City Council to form a White-Tailed Deer Task Force to analyze deer densities and impacts and to study methods and local practices to manage deer populations. Relying heavily on Montgomery County-level data and presentations from local experts, the task force used aerial surveys of deer densities in Rockville from the mid-90s, deer-vehicle collision data, and anecdotes from city staff to craft a Rockville-specific deer management plan. The *City of Rockville White-Tailed Deer Management Plan* was released in 2012. The plan outlined deer-vehicle collisions, Lyme disease, and harm to landscaped gardens and ecological communities as primary concerns. The plan outlined various non-lethal, deer management methods, (i.e., deterrence, fencing, traffic control devices, repellents, or continued tolerance) to be used where deer presented a safety hazard. The plan also recommended that deer densities be monitored using camera surveys annually (White-tailed Deer Task Force 2012).

The City of Rockville Recreation and Parks Department summarized data on deer densities and effects in their 2015 annual report and found no improvement in reducing deer impacts. Based on camera surveys of two city parks, deer densities (i.e., Fallsgrove Park: 92 deer per square mile; Montrose Park: 161 deer per square mile) were higher than their target of 25–30 deer per square mile, which had been recommended by MDNR as a sustainable deer density in urban forests in the 2012 plan. No reduction in deer-vehicle collisions was observed between 2009 and 2015. Residents continued to complain about deer damaging plants on their property or sought advice on deer resistant plants and deterrents.

In 2020, the City of Rockville piloted its first use of lethal control and allowed archery hunting in public parks. By that year, deer densities ranged from 130–160 deer per square mile across 6 parks (Masters 2019).

Great Falls is a priority area for deer management at **Chesapeake and Ohio Canal National Historic Park** (COCNHP), located northeast of Arlington and along the Potomac River. In 2017, NPS released a joint White-tailed Deer Management Plan and Environmental Assessment for COCNHP and Harpers Ferry National Parks. A primary objective of the plan was to reduce documented negative effects of deer overabundance on forest health. Deer surveys starting in 2010 at COCNHP recorded consistently high deer densities, well above a 20 deer per square mile benchmark to allow forest regeneration (National Park Service 2017). Monitoring of vegetation in long-term open plots and exclosure studies (paired unfenced and fenced plots) linked deer browsing to poor forest regeneration (McShea and Bourg 2009). Other objectives of the plan included reducing deer browse of cultural landscapes, facilitating coordination with nearby entities already implementing deer management, and proactively addressing the nearby threat of CWD (National Park Service 2017).

Similar to RCP described earlier in this report, the management plan outlines four alternatives: A) status quo, including monitoring, research, small-scale fencing of native species and sensitive areas; B) status quo + non-lethal methods of protecting vegetation including large-scale fencing; C) status quo + lethal methods to reduce deer numbers; and D) status quo + lethal methods (i.e., sharpshooting) to initially reduce deer densities + non-lethal reproductive control to maintain target deer numbers. Within alternative B, non-surgical reproductive control was also proposed to control deer populations in restoration areas if feasible. A CWD management plan was included with each alternative (National Park Service 2017). NPS adopted alternative D in 2018; lethal control, using sharpshooting, began that same year (National Park Service 2018b.) Venison was donated to a local food bank.

Thresholds for action include: 1) deer densities above 15–20 deer per square mile; 2) at low deer densities (13–20 deer per square mile), a minimum of 10 seedlings per plot in at least 67% of plots; at high deer densities (56–64 deer per square mile), a minimum of 30 seedlings per plot in at least 67% of plots; and 3) crop yield loss of 75% below average yields (National Park Service 2017).

Prince George's County Deer Management Program involves lethal control (hunting and sharpshooting) to reduce deer numbers in public parks (Prince George's County 2022). M-NCPPC partners with MDNR to manage public hunting in five parks, designated as Cooperative Wildlife Management Areas. In two of the parks, archery, muzzleloader, shotgun, and primitive weapons (i.e., longbows, recurve bows or flintlock and sidelock percussion muzzleloading rifles or handguns) are permitted; while three parks are archery only. Sharpshooting is implemented by Prince George's County Department of Parks & Recreation Park Ranger Unit and Park Police Division across 16 parks. Meat harvested from sharpshooting operations is donated to local food banks.

Prince George's County collects annual deer-vehicle collision data, in collaboration with Prince George's County Animal Control, which is mapped to GIS. In select parks, deer density surveys are being conducted. Prince George has set a deer density target of 20 deer per square mile. Areas with deer densities above that are considered for deer management; however, there was no mention of vegetation/browse surveys.

Herbivory Impact Assessments in Arlington

So far, we have explored Arlington County DPR natural resource stewardship goals, ecological carrying capacity of deer in forests, and how adjacent jurisdictions have managed deer populations. We now report on white-tailed deer herbivory impact assessments in Arlington DPR parklands. We used two methods to assess browse impacts and summarize those methods and results here. Full results from these efforts are presented in the appendices of this report.

Many woody and palatable herbaceous species have been proposed as indicators of deer browse severity in North America (Anderson 1994, Williams et al. 2000, Kraft et al. 2004, Pierson and deCalesta 2015, Royo et al. 2016), but there is a need for researchers and practitioners to develop simple, low-cost methods for evaluating deer impacts (Curtis 2020). The ten-tallest method (Rawinski 2018) was used for this project, a method designed to be simple, easy to learn and apply, and may work better in practice for students, citizen scientists, and managers (Waller 2018). In testing, this method produced data distributions with low variance in the Finger Lakes region of New York State (Quirion 2022). The ten-tallest method monitors deer impacts by collecting data on height, whether individual woody stems are browsed (yes/no), and number of reproductive individuals in the plot. This method evaluates existing plant populations, can be monitored across years, and may be used across a wide range of forest types. The data collected and used by the ten-tallest method over multiple growing seasons make this method suitable for informing deer management over the long-term (Quirion and Blossey 2023). In an additional four parks, we used another browse survey method based on Pierson and deCalesta (2015), modified for smaller park sizes. This method uses randomly selected four-foot radius plots where researchers record up to 5 levels of deer browsing impact (i.e., not browsed through severely browsed) on multiple plants within each plot. Fairfax County uses similar methods to Pierson and deCalesta (2015), so adopting this additional survey protocol allows for data to be shared and compared between the two municipalities.

Ten-tallest method for assessing deer impacts

White Buffalo Inc. subcontracted Thomas Rawinski to collect data using the ten-tallest method in Arlington Parks. He has spent his 39-year professional career studying the vegetation of eastern North America and is an acknowledged expert in deer impact assessment and mitigation. Most recently, he served as a botanist with the U.S. Forest Service. In 2020–2021, he was a recipient of the prestigious Harvard University Charles Bullard Fellowship in Forest Research, where he synthesized information on white-tailed deer overabundance. He also lived in Virginia during the 1990s, serving as Vegetation Ecologist for the Virginia Natural Heritage Program. Results are summarized below, with the full report available in Appendix A.

Measurements were collected within plots at Barcroft, Benjamin Banneker, Bluemont, Bluemont Junction, Bon Air, Donaldson Run, Glencarlyn, Gulf Branch, and Windy Run Parks. In all, 22 plot centers were established and 31 plant populations were sampled. These populations comprised 13 species, some sampled at multiple sites. Overall, 88% of all stems examined across Arlington exhibited browse damage by deer. By species, assessed browsing ranged from 100% of chestnut oak (*Quercus montana*), strawberry bush (*Euonymus americanus*), winged euonymus (*Euonymus alatus*), catalpa (*Catalpa speciosa*), and black cherry (*Prunus serotina*), to a low of

10% for eastern red-cedar (*Juniperus virginiana*). Most of Arlington's parklands could be categorized as moderately browsed, with high impact found in some areas (e.g., northern Donaldson Run and Windy Run). Low impact areas were few. Ultimately, tree regeneration failure in Arlington parks along stream and habitat corridors that were sampled were widespread, and deer impacts unusually pervasive. In many areas small tree saplings were plentiful, but it remains to be seen whether they will grow out of the browsing height of deer. Common among the site locations in the parks was a high percentage of individual stems being browsed.

Steward Green™ forest health assessment

For four additional parks where the aerial drone survey indicated deer were present, White Buffalo Inc. subcontracted Steward Green™, ecosystem services consultants with expertise in habitat analysis and reforestation. The full report from Steward Green™ is presented in Appendix B. Four smaller properties within the Arlington County Park system, Doctor's Run Park, Fort C.F. Smith Park, Fort Bennett Park, and Grandma's Creek (a sub parcel of Glencarlyn Park), were assessed for deer browse impacts on understory vegetation within forested areas. Monitoring was performed by quantifying deer browse intensity on native understory species using methods modified from Pierson and deCalesta (2015) and current composition and density of forest understory per VanClef (2022). Using data collected from ten randomly selected study plots at each park in early November 2022, it was determined that all properties exhibited signs of overabundant deer browsing. Mean deer browse rates on native understory in the study plots ranged 83–92%, well above limits desired by Steward Green™. Most common was the "moderate" level of deer browse impact, defined as greater than 50% of twigs browsed, without any signs of hedging. Hedging refers to stunted plants with stems browsed to thick stubs from deer browsing (Pierson and deCalesta 2015). Outside the random study plots, however, the researchers observed areas with severe browse impact such as at Fort C.F. Smith and Grandma's Creek.

Steward Green™ also used their Secchi method to assess understory composition with a minimum of 70% native vegetation cover in the understory as a benchmark for a recovered forest. Understory composition varied from 21% native cover at Grandma's Creek to 65% native cover at Fort Bennett Park. Fort C.F. Smith and Doctor's Creek had 58% and 63% native cover, respectively.

Deer Impact Mitigation Methodology

So far, we have explored Arlington County DPR natural resource stewardship goals, ecological carrying capacity of deer in forests, how adjacent jurisdictions have managed deer populations, and white-tailed deer herbivory impact assessments in Arlington DPR parklands. Here we review modern deer impact mitigation methods that have been used in other urban landscapes that might have application in DPR lands for alleviating deer browse pressure. Regardless of methods adopted, we note that annual maintenance is generally required to keep deer populations within municipality density objectives.

Lethal methods

Lethal deer management methods such as professional sharpshooting or public hunting have been used in urban and suburban landscapes with a goal to reduce deer populations and associated negative impacts. As described below, these lethal methods differ in efficacy.

Professional sharpshooting.- We define professional sharpshooting as the systematic culling of deer by trained sharpshooters at night using suppressed firearms with ammunition designed to be humane for deer and safe for use in urban or suburban landscapes. The use of sharpshooting has demonstrated a reduction in deer-vehicle collisions (DeNicola and Williams 2008) and increased forest regeneration (Abella et al. 2022). Pros of professional sharpshooting include efficiency compared to other lethal and nonlethal methods; safety for the public; cost savings compared with surgery; meeting euthanasia standards set by the American Veterinary Medical Association (instantaneous); use of non-lead ammunition, designed to be safe and humane, discharged from elevated stands; and donation of venison. Costs for sharpshooting per deer vary but are generally half that of surgical sterilization described below. A recent study suggested that the estimated cost to cull 100 deer on an island in 2018 was $552.72 per deer, including expenses such as salary, truck rental, fuel, refrigeration, supplies (e.g., ammunition and ice), bait, meat processing, mileage, and barge expense (Walker et al. 2021). Currently, however, it remains illegal to discharge a firearm within Arlington County, requiring a change to County Code to allow for its use.

Public hunting.- We define public hunting, in terms of application in Arlington, as the pursuit and harvest of deer by licensed and vetted hunters for food or sport using archery equipment from elevated stands in urban or suburban landscapes. Public hunting offers opportunity for hunters where permissible under existing County Code outside of 100 yards of a structure, road, or property; however, few such areas exist for DPR lands without changing County Code restrictions, currently limiting hunting space and opportunity. It is already legal for people to archery hunt in Arlington County (J. Green, Virginia Department of Wildlife Resources, personal communication). Arlington technically also has extended early and late firearms seasons, but since Arlington prohibits the discharge of firearms, only archery is allowed during those times. Since 2005, archery hunters have harvested less than 20 deer annually within the County. Currently, there is limited archery hunting in the Arlington Army Navy Country Club. The use of controlled hunting as a stand-alone method to increase forest regeneration has been questioned in the peer-reviewed literature (Williams et al. 2013, Blossey et al. 2019). Finally, unlike sharpshooting, hunting does not provide an instantaneous death. Consideration of combining hunting with other management options to achieve DPR stewardship goals may be necessary given the potential impediments to hunting efficiency. Ultimately, however, hunting does remove some animals from the landscape, may serve as a stop-gap approach to make inroads to other more efficient methods (e.g., sharpshooting), or may serve as a hybrid approach in combination with other population control methods. Costs of running a hunting program vary but could be high if full-time DPR staff are needed for this management method.

Non-lethal methods

Despite the potential benefits of lethal methods, these may not be feasible or effective in many urban and suburban landscapes due to social, legal, economic, or public safety considerations (Williams et al. 2013, Kilpatrick et al. 2014). Non-lethal methods include trap and relocation, fertility control, fencing, and repellents. Interest in fertility control in wildlife populations continues to grow in the scientific literature (Palmer et al. 2018, Yang et al. 2023) and among the public for deer specifically (Rutberg et al. 2013*a*). These experimental methods have shown mixed results for use on localized urban and suburban deer populations, as detailed below.

Trap and relocation.- We define trap and relocation as the process of trapping deer, transporting them to another location, and releasing them into the new environment. Rarely practiced, trap and relocation programs are generally not considered because the method may be stressful to deer, resulting in high post-release mortality (Beringer et al. 2002). Moreover, Arlington falls within a CWD quarantine zone, which would prevent the relocation of County deer elsewhere.

Immunocontraceptive vaccines.- Experimental use of immunocontraceptive vaccines have been applied to female deer to reduce births. Pros of vaccine technology may include the use of a nonlethal method desired by some people. For long-lived species such as deer and horses (*Equus* spp.), at least one booster is necessary to predictably maintain >90% effectiveness for >2 years (Gionfriddo et al. 2011, Rutberg et al. 2013*b*, Roelle et al. 2017). Relocating and capturing previously vaccinated deer may be problematic for future booster shots given their learned behavior and increasing wariness of capture methods. A recent study demonstrated poor efficacy and high costs with treating free-ranging white-tailed deer with GonaCon™ (Walker et al. 2021). Another immunocontraceptive vaccine, PZP (porcine zona pellucida), has been used to reduce deer numbers in Hastings on the Hudson, New York (Rutberg and Pereira 2021). In that study, deer populations declined approximately 62% between the first year of the study (2014) and 2019; moreover, deer-vehicle collisions were reduced. Despite these successes, peer-reviewed literature and approximate cost per deer for this study are unavailable as of this writing. Experimental use of immunocontraceptive vaccines would need approval by DWR and an Arlington ordinance change to allow discharge of darts.

Surgical sterilization.- We define surgical sterilization as the removal of ovaries from female deer to prevent pregnancy. Deer are drawn to select areas using bait for sterilization capture. Female deer of all age classes are captured using remote immobilization (darting) techniques. Deer are then transported to a temporary veterinary surgical sterilization site. Ovariectomy surgeries are then performed by licensed veterinarians experienced in the procedure and anesthesia. Post-surgery, deer are fitted with numbered livestock ear tags and then transported and released at or near the site of capture. Deer are monitored by project staff until they are ambulatory.

Unlike immunocontraceptive vaccines, surgical sterilization renders female deer sterile after a single treatment (MacLean et al. 2006, Gilman et al. 2010), eliminating costs associated with recapture and administering booster doses of immunocontraceptive vaccines (Boulanger and Curtis 2016). Surgical sterilization has reduced deer populations in suburban landscapes at lower costs ($927–$1,572 per deer based on first year of treatment) when compared to vaccine technology in some circumstances (DeNicola and DeNicola 2021). Researchers have conducted surgical sterilization in multiple sites with geographically open deer populations including California, Maryland, Michigan, New York, Ohio, and Virginia. From that study, four years after initial surgical sterilization surgery, an average population reduction of ~45% (29–56%) was attained (DeNicola and DeNicola 2021). A single study has suggested that sterilization of female deer was unable to reduce deer browse rates on vegetation (Blossey et al. 2019). However, that study was based on efforts that used two sterilization techniques, including tubal ligations which is less efficient at reducing deer populations (Boulanger and Curtis 2016). As of this writing, no peer-reviewed literature has demonstrated that surgical sterilization with the sole use of ovariectomies can lead to regeneration of forests. Pros of surgical sterilization may include the use of a nonlethal method desired by some people. Cons for this method include the limitation of land area and scale, higher costs and delayed results compared to sharpshooting, and the limitation to its experimental use as vetted through the State. Moreover, deer capture for sterilization efforts is best conducted with dart projectors and chemical immobilization, again requiring a change to Arlington County Code. Finally, we note that successful implementation of surgical sterilization in Arlington would include neighboring properties that surround DPR lands to have better access for deer capture and treatment, and thus would require community buy-in.

Surgical sterilization may also include the use of vasectomies on male deer. There is currently only one large-scale study underway, located in Staten Island, New York, assessing the experimental use of vasectomies to reduce suburban white-tailed deer populations and associated impacts (New York City Parks and Recreation 2024). One male deer may impregnate many females, so this method relies on almost all males being sterilized in a given area. While the Staten Island project is showing promise, overall success of population reduction using this method is greater for insular or island deer herds where the effects of male deer immigration can be minimized (Boulanger et al. 2012). Arlington is an open landscape with few constraints on immigration, thus making this approach less likely to succeed in Arlington.

Fencing.- In smaller suburban woodlands, a deer-proof fence may provide a solution. A fence height of 8' has been reported to be 90–99% effective at excluding deer; however, deer have also been reported to crawl under fences with openings as low as ~7.5–10" (VerCauteren et al. 2010). Thus, an 8' fence with no bottom gaps ≥7.5" is recommended as a minimum to exclude deer from a given area. However, a higher fence would clearly provide additional protection. Ten-foot fence designs have also been recommended in the literature for deer exclusion (Craven and Hygnstrom 1994), and this height is also recommended by the Federal Aviation Administration to protect human safety at airports (Federal Aviation Administration 2016). We define fencing as the installation of an 8-foot fence (minimum) surrounding a park or plant community, or a smaller fence around an individual plant. Pros of this method include effectiveness for small areas or individual plants, and Arlington County zoning allows for 8-foot fencing on parklands. Cons for this method are several fold. Fencing installation could harm sensitive natural areas, requires maintenance, displaces deer elsewhere, and may be cost prohibitive at scale. Moreover, fencing could require involvement of other non-County jurisdictions that border DPR lands. Finally, fencing does not allow for the spread of native vegetation outside of these protected areas, so restoration only occurs inside fenced areas.

Larger fenced areas will need gates for public access, and these gates must be opened and closed without letting deer into the exclosure. Some deer do learn to enter main gates during the times they are open, even if briefly. Some communities have installed cattle guards at main entry gates given the difficulty deer have crossing these barriers. Research suggests that cattle guards are 95–98% effective (Belant et al. 1998), and this is something to keep in mind should fencing become a possibility in DPR lands. Those entities that use fencing to exclude deer from sensitive areas must also have a plan in place should deer breach the fence. Despite the limitations of fencing as described here, fencing can still be effective for some areas, and may be considered also as a hybrid approach in combination with other management options to achieve DPR management goals.

Repellents.- We define repellents as homemade or commercially available products that are applied to plants that make them unpalatable to deer. While repellents may be effective for small areas or individual plants, they are impractical to implement at the scale needed for DPR lands. Specifically, repellents require regular application (e.g., including after rainfall) and are cost and labor prohibitive at larger scales. Effectiveness of deer repellents vary, and new products often come to market with limited experimental testing (Curtis and Boulanger 2010). Repellents are currently being used in some sensitive areas on DPR lands such as the Bon Air Memorial Rose Garden (A. Abugattas, DPR, personal communication), and this method at best has limited use in combination with other deer management methods.

Public Engagement in Arlington

In summer 2023, we collaborated with DPR to engage Arlington County residents on the state of the ongoing deer project. We also solicited opinions of potential management strategies to mitigate deer impacts and facilitated the generation of additional thoughts on issues or approaches for Arlington deer management. These public outreach events included an online feedback form (2,524 participants), a community forum (75 participants), and two focused deep dive conversations (25 participants). Full results from public engagement will be made available from DPR. Here we outline some details from these public outreach efforts.

Online Feedback Form

From June 15 to July 18, DPR hosted an online feedback form to solicit opinions related to deer management in Arlington. This form was designed as a questionnaire and as an opportunity for open feedback. Below we summarize responses to questions related to participant's level of concern and level of support for potential deer management options. For questions below pertaining to level of support, participants were given a choice of a 5-point scale including very supportive, supportive, neutral, unsupportive, and very unsupportive. Here we truncate these data into three categories: 1) supportive, 2) neutral, and 3) unsupportive.

On a scale of 0 to 5, participants were asked how they would describe their level of concern regarding the impact of overbrowsing on deer health and Arlington's ecosystem (0 being no concern at all and 5 being very concerned). Almost half (47%) reported concern at the level of 4 and 5 combined; 20% reported no concern.

Participants were asked about their level of support regarding the recommendation for Arlington to develop a deer management implementation strategy for Arlington County Parks. 55% and 35% of participants were supportive or unsupportive of Arlington developing a deer management implementation strategy, respectively; 7% remained neutral.

Participants were asked about their level of support regarding specific deer management implementation strategies for Arlington County Parks. These strategies were divided between lethal (professional sharpshooting and public archery hunting program) and nonlethal (surgical sterilization and fencing) categories.

Professional sharpshooting (lethal).- 43% and 51% of participants were supportive or unsupportive of professional sharpshooting, respectively; 4% remained neutral.

Surgical sterilization (non-lethal).- 63% and 24% of participants were supportive or unsupportive of surgical sterilization, respectively; 11%% remained neutral.

Public archery hunting where permissible (lethal).- 34% and 60% of participants were supportive or unsupportive of public archery hunting, respectively; 6% remained neutral.

Fencing entire parks (non-lethal).- 31% and 56% of participants were supportive or unsupportive of fencing entire parks, respectively; 12% remained neutral.

Community Forum

On July 11, 2023, 75 participants were present for a community forum where project background, browse survey results, and potential management options were presented by DPR staff and the author of this report. The latter part of this forum was the generation of responses and discussion related to two general questions:

1. Having reviewed the options available, which ones are you most supportive of and why?
2. Which strategies are you most concerned about and why? Are there any ideas that you think are missing?

For question #1, there was a general lack of consensus on deer management methods, with some preferences for sharpshooting, sterilization, and hybrid approaches, and conversely, opposition to lethal methods. Moreover, there were requests for science- and evidence-based analysis and a need for broader perspective and less harmful approaches to deer management. For question #2, The community voiced concerns about the effectiveness of fencing and sterilization. Participants expressed a need for ongoing monitoring, a demand for immediate action, and expressed ethical concerns with the use of archery hunting. The community also expressed a preference for park-specific solutions, given the unique circumstances of each park.

Deep Dive Conversations

Two separate web-based deep dive conversation sessions were held on July 13 and 17, 2023 to garner input from 18 key stakeholders on focused topics related to the project. Those stakeholders present included the following:

Animal Welfare League of Arlington, Arlington Outdoor Lab, Arlington Regional Master Naturalists, Audubon Society of Northern Virginia, Barcroft School & Civic League, Bluemont Civic Association, Civic Federation, Donaldson Run Civic Association, Earth Sangha, Forestry and Natural Resources Commission, Four Mile Run Conservatory Foundation, Friends of Gulf Branch Nature Center, Glencarlyn Civic Association, Northern Virginia Bird Club, NOVA Parks, Plant NOVA Natives, Tree Stewards, and Virginia Cooperative Extension

All responses from the following three questions have been condensed into several themes.

Deep Dive question #1: *Were there any findings from either the browse report or explainer video that most interested you?* Themes condensed from this question included 1) education is crucial for residents in highly populated areas; 2) broadening the reach of the browse report and explainer video; 3) urgent issues not addressed in the browse report (e.g., CWD, deer meat consumption, cost); and 4) some concern that non-lead ammunition and lead fragments might end up in harvested meat.

Deep Dive question #2: *Having reviewed the deer management options that are most suitable for Arlington, which ones are you most supportive of and why?* Themes condensed from this question included 1) the importance of taking action (vs. no action); 2) support for controlled culling; 3) mixed opinions on fencing and repellants; 4) experience from Fairfax County and urgency in conservation; and 5) use of humane approaches and hybrid solutions.

Deep Dive question #3: *Which of the management options are you most concerned about and why? Are there any ideas that you believe are missing?* Themes condensed from this question included 1) concerns about surgical sterilization; 2) implications of fencing; 3) need for education and information dissemination; 4) unaddressed issues and involvement of local groups; and 5) role of deer in spreading invasive plants.

In sum, the community meeting and deep dive conversations helped inform future education and engagement efforts, while information gleaned from the public feedback form suggests additional support for implementing some deer management solutions. Almost half of those responding to the public feedback form reported concern for deer browsing in Arlington parks and support for developing deer management strategies. Specifically, large proportions of participants supported professional sharpshooting and surgical sterilization with less support for public archery hunting and fencing. These findings, paired with the recent deer population and vegetation impact surveys demonstrating that DPR goals are not being met, suggest a path forward with some management options. Taken together, we provide deer management recommendations for DPR in the following section.

Management Recommendations for Arlington

Immediate Recommendations

We recommend sharpshooting as the primary management method to reduce deer populations and associated impacts on DPR and any other County-owned natural land parks. The use of sharpshooting has demonstrated a reduction in deer-vehicle collisions (DeNicola and Williams 2008) and increased forest regeneration (Abella et al. 2022). Again, the pros of professional sharpshooting include efficiency compared to other lethal and nonlethal methods; safety for the public; cost savings compared with surgery; meeting euthanasia standards set by the American Veterinary Medical Association (instantaneous); use of non-lead ammunition, designed to be safe and humane, discharged from elevated stands; and donation of venison.

If sharpshooting is not feasible for some Arlington parks, we recommend as a backup plan the use of surgical sterilization or a hybrid approach using a combination of methods to reduce deer populations. For example, a proportion of deer may be initially sterilized, followed by sharpshooting on remaining animals that have not been sterilized. Sterilized deer receive large ear tags so that sharpshooters will not harvest these animals. The rationale for sterilizing deer first is that capturing deer is more difficult than sharpshooting (Boulanger et al. 2012). In other words, it is easier and more cost effective to first capture, sterilize, and mark deer with visible ear tags, followed by sharpshooting a proportion of the remaining unsterilized deer. Otherwise, once deer have been exposed to sharpshooting, they become more wary and harder to catch for sterilization surgery. However, the order of these methods is not as critical if sterilization and sharpshooting are separated into different management areas. Compared to sharpshooting, however, no peer-reviewed literature has demonstrated that surgical sterilization with the sole use of ovariectomies can lead to regeneration of forests. Moreover, higher costs and delayed results, and the limitation to its experimental use as vetted through the State remain cons. Finally, we note that successful implementation of a surgical sterilization program in Arlington would need to include neighboring properties to have better access for deer capture and treatment, and thus would require community buy-in.

Archery hunting has clearly demonstrated a reduction of local deer densities via regulated hunting; however, hunting is not supported in the peer-reviewed literature for reducing populations sufficiently for forest regeneration (Williams et al. 2013, Blossey et al. 2019). Moreover, public archery hunting was not as supported among Arlington residents who provided feedback, and it is not likely practical on narrow DPR lands. That said, this method has provided benefits to jurisdictions surrounding Arlington County, and could be used as a stopgap method to harvest some deer if other methods are not feasible in the short-term.

Finally, in areas where sensitive species are being browsed by deer, we recommend smaller plots of temporary or semi-permanent fencing, until deer population numbers are more in equilibrium with forest regeneration. Use of sharpshooting, surgical sterilization, and archery hunting, however, require a change in County Code (Arlington County 2024a).

Follow-up Recommendations

Thus far we have provided deer management recommendations only for Arlington DPR-owned lands. If Arlington implements deer management methods and robust monitoring but is not achieving forest regeneration goals over a desired timeframe, then we recommend a geographically expanded hybrid approach that integrates sharpshooting within DPR park boundaries and concomitant use of surgical sterilization on surrounding private lands. Surgical sterilization may be conducted safely in dense suburban landscapes whereas sharpshooting would be restricted to within park boundaries. Preventing fawn births via sterilization is designed to help reduce immigration into DPR lands.

We also recommend open communication and possible collaboration with other jurisdictions within Arlington such as NPS and NOVA parks. These collaborations, along with those in adjacent jurisdictions outside of Arlington may inform a regional approach to deer management that may further benefit forest regeneration.

Monitoring Recommendations for Arlington

Browse Surveys

Recommended browse surveys.- We recommend continued monitoring using methods modified from Pierson and deCalesta (2015) as presented in this report. As deer populations are reduced in Arlington lands, DPR management thresholds for this method should be "light impact" browsing as described earlier in this report. We also recommend methods being conducted at Rock Creek Park which are based on established, peer-reviewed protocols described by Krafft and Hatfield (2015). In short, 1 x 4-meter herbivory study modules consisting of paired fenced plots and unfenced control plots were installed in 2000 and have been monitored annually to test whether herbivory was causing negative impacts. Results from these studies clearly demonstrated 1) negative impacts of deer herbivory (Rossell et al. 2007, Krafft and Hatfield 2011, 2015) and 2) forest recovery (i.e., increased seedling survival) after initiating a deer management program to reduce deer densities. The Krafft and Hatfield (2015) method provides an excellent opportunity for public demonstration of the difference between healthy forest regeneration vs. current conditions and aligns with the Arlington County Forestry and Natural Resources Plan (Arlington County 2024b) recommendation to "enlist and train residents to participate in monitoring flora and fauna". Like RCP, we recommend establishing a threshold for action based on a minimum seedling density of 51 seedlings per plot within 67% of unfenced long-term plots. For both recommended browse surveys, Arlington would be collecting data like regional jurisdictions (e.g., Rock Creek Park and Fairfax County), which together, can inform more robust landscape-level analyses of deer overbrowsing regionally.

Supplementary browse surveys.- If feasible, we also recommend continuing the ten-tallest method presented in this report. The ten-tallest survey locations are already fixed in the DPR landscape, allowing staff to directly compare annual changes to stems due to deer browsing at these locations. These survey plots provide another excellent opportunity for public demonstration and involving the public with assessing annual changes to stems. As deer populations are reduced in Arlington lands, DPR management thresholds for the ten-tallest method should be “low” browsing as described by (McWilliams et al. 2018).

DPR may also consider supplementary and experimental use of sentinel seedlings as described by Blossey et al. (2019) to further assess negative herbivory impacts in Arlington parklands. In short, 40 native red oak (*Quercus rubra*) seedlings are planted in a plot, half of which are protected by cages. Over time, herbivory on unprotected oaks is monitored and compared to controls, with the expectation that if deer are at or under carrying capacity, some will escape deer herbivory once terminal shoots grow out of browse height. Arlington parklands are home to red oaks, which means following the study methods is appropriate here. This method could also be applied with other similar species in Arlington, if those are considered more appropriate for planting in a given site. For example, chestnut oak (*Quercus montana*) is preferred by deer along with red oaks (Arnold and Welch 1996), and are found in DPR lands, so sentinel seedlings from this species may also have potential. Management thresholds for this method should be survival of any of the seedlings within each plot, answering the question as to whether Arlington can grow oak trees without exclusionary fencing, and relate that to ongoing deer density estimation.

Ultimately, DPR will need to combine literature review, regional precedent, deer population surveys, and browse impact surveys to determine how many deer its forests can healthily sustain. Research suggests that a deer density at approximately 20 deer per square mile may be the desired metric for regeneration (Drake et al. 2002, Horsley et al. 2003, Waller and Alverson 1997, and Abella et al. 2022), but Arlington may differ. For now, we recommend this goal as a starting point. Should Arlington reduce deer numbers on DPR lands, it will be critical to compare results from ongoing browse and deer density monitoring. Deer per square mile goals for DPR lands may change based on regeneration success.

Population Estimates

While browse survey monitoring is of primary importance, deer population density estimates are another supplemental metric that can inform conservation and management decisions. For example, an estimate of deer populations in a given area can inform the number of deer to target in a sharpshooting or surgical sterilization program. Various estimation methods are available to decision-makers, each with advantages and disadvantages. The techniques typically used to estimate the abundance of deer include UAS (drone) equipped with thermal infrared sensors (Beaver et al. 2020), spotlight surveys, other aerial infrared scanning or snow counts, mark-recapture/resight, and population reconstruction (Downing 1980). Should periodic and robust deer population estimates be implemented, Arlington may then use these data to inform target numbers for management operations (e.g., sharpshooting or surgical sterilization) and relate these estimates to plant and tree recovery.

Aerial drone surveys.- In recent years, suburban deer population estimates have benefitted from drone and infrared sensor technologies. We recommend that DPR bolster their efforts to assess deer impacts with standardized and periodic aerial drone deer population estimates, like those described earlier in this report. While other deer population estimate methods such as camera surveys are available, these methods may be less efficient (Delisle et al. 2023).

Camera surveys.- Based on tagged antlered males, a mark-recapture/resight method called the Jacobson's buck:doe method (Jacobson et al. 1997, Weckel et al. 2011) has been used in suburban landscapes. Mark-resight with camera traps has successfully estimated the population size of free-ranging deer with a portion marked with ear tags (Curtis et al. 2009). These researchers documented that using IRC cameras with the Jacobson BDR method provides a reliable estimate of the abundance of suburban white-tailed deer herds. However, camera theft in busy parks remains a serious issue for the implementation of camera surveys in these landscapes.

Distance sampling surveys.- Depending on deer numbers and evasiveness of deer in parklands, DPR may consider spotlight distance sampling methods (Buckland et al. 2001) from UTVs or motor vehicles within park boundaries. The distance sampling approach is based on the premise that you can determine the width of a transect traveled by creating a detection probability from the field observations (i.e., number of deer and distance from the transect). In simple terms, the software program (e.g., Program Distance; Thomas et al. 2010) projects the area sampled and then integrates the number of deer observed in that area to determine density. First, a delineated non-overlapping spotlighting route is drafted for DPR lands and surveys are then conducted at night. While driving 10 mph, spotters search their respective sides of the road or trail with 2,200 lumen spotlights. Upon sighting deer, the number in each social group, age and sex of the individuals (when it can be determined), and the perpendicular distance to the group are recorded. These data are then entered into the software program that estimates deer density for the area surveyed. However, this method requires 20–30 groups of deer spotted to provide a reliable estimate, which may not be possible depending on the number of deer available, whether deer remain on DPR lands during spotlight efforts, or level of deer evasiveness from spotlighting efforts. If needed, estimate precision can be improved by integrating community roads surrounding parks, allowing for potentially more deer to be counted.

Vehicle Collisions and Deceased Deer Intakes

Deer-vehicle collisions are a large cause of mortality in Virginia (A. Lombard, Wildlife Health Coordinator, Virginia Department of Wildlife Resources). Based on 2021–2023 data, 19 deer-vehicle collisions were reported in Arlington (Virginia Department of Transportation 2024). However, research suggests that about half of all deer-vehicle collisions go unreported (Romin and Bissonette 1996). In Virginia, deer-vehicle collisions may have been unreported if a driver did not call the police or if the crash did not meet reportability thresholds for injury or personal property damage under state law (Virginia Law Portal 2024).

In addition, sick, injured, or dead deer are reported by animal control contractors within Arlington County, but these data cannot easily be used to assess deer-vehicle collisions without cause-of-death determination. To date, animal control data suggest that the number of deceased deer intakes are rising (Fig. 2). General locations of these deceased deer intakes may also be used to create density maps to identify "hot spots" in Arlington County (Fig. 3) which may inform focal areas for increased monitoring and proximity to DPR lands. We highly recommend training for Arlington animal control contractors that intake or pick up dead deer that would inform the cause of death from vehicle collisions. Tracking deer-vehicle collisions is a key component to a comprehensive deer population monitoring or management plan to promote public safety and to provide index data to inform management progress or success.

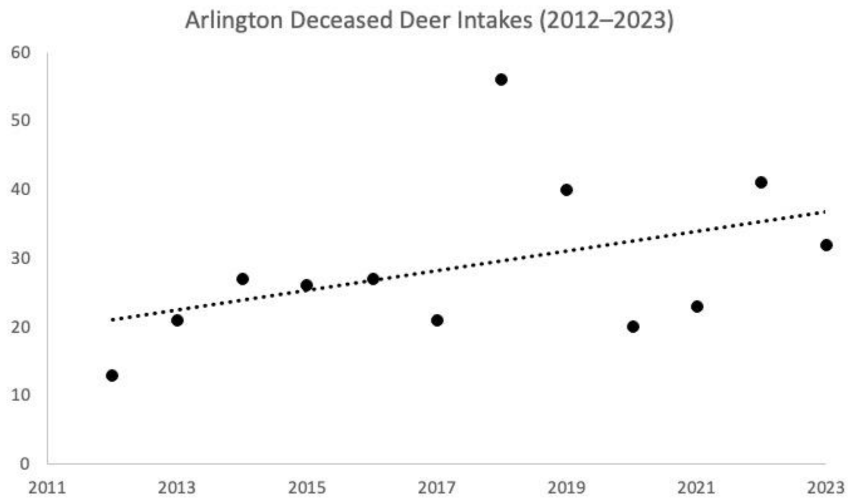

Figure 2. Arlington County deceased deer intakes as reported by animal control, 2012–2023.

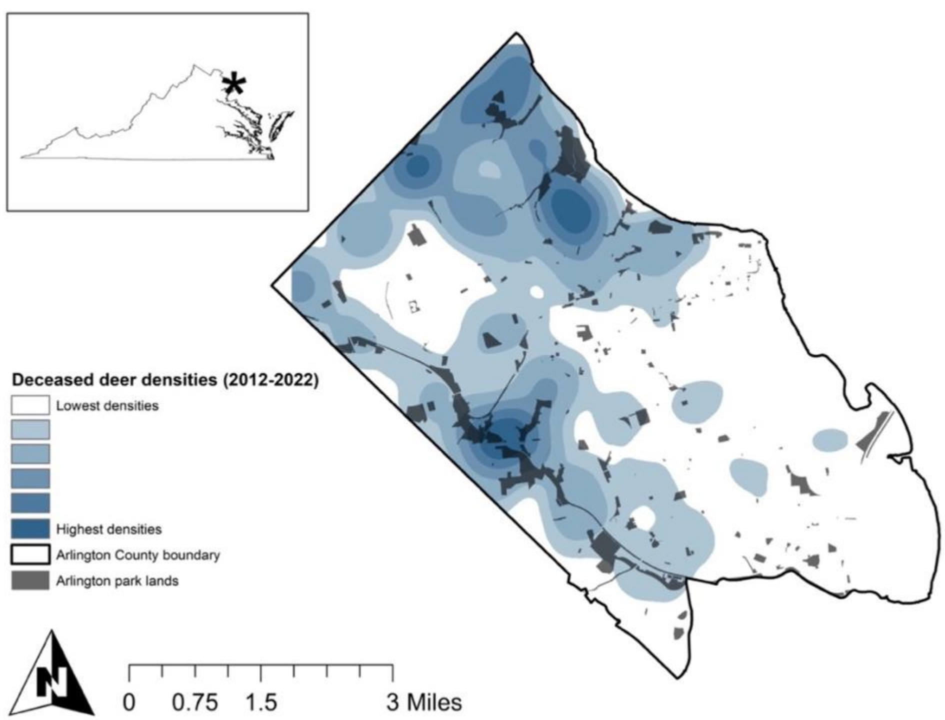

Figure 3. Estimated densities from deceased deer as reported by animal control based on generalized pickup locations in Arlington County, 2012–2022.

Human Disease Tracking

High deer populations are a human health threat in some areas due to amplification of tick populations and prevalence of tick-borne diseases (Raizman et al. 2013, Kilpatrick et al. 2014). The Virginia Department of Health (2024) lists 12 tick-borne diseases within the state. Lyme disease from blacklegged ticks (*Ixodes scapularis*) is reported in Virginia, and in Arlington County, there were 32 confirmed cases from 2018–2022 (U.S. Centers for Disease Control and Prevention 2024). Lyme disease cases in Arlington seem low compared to some parts of the northeast and mid-Atlantic states. Another tick-borne infection, acquired red meat (alpha-gal) allergy from lone star ticks (*Amblyomma americanum*), is on the rise in Virginia. Should the prevalence of Lyme or other tick-borne diseases begin to increase, we recommend tracking as an integral part of Arlington's deer management.

Impending Wildlife Disease Issues

Chronic Wasting Disease.- CWD is a transmissible and invariably fatal disease found in white-tailed deer (Edmunds et al. 2016). Although found in neighboring Fairfax County, CWD has not yet been confirmed in Arlington (Virginia Department of Wildlife Resources 2024). However, Arlington is included in the Virginia CWD Disease Management Area, so any methods such as sharpshooting and surgical sterilization that require use of bait for capture of deer would also need special approval by DWR. CWD testing for hunters in Virginia is voluntary, except for mandatory CWD check stations on opening day of firearms season in other counties (J. Green, District Wildlife Biologist, Virginia Department of Wildlife Resources). To be considered for testing, Arlington deer must be adults and would need to display clinical symptoms such as a wide sawhorse-like stance, emaciated appearance, drooling, and drooping ears. If a deer looks questionable, residents are encouraged to call the DWR toll-free wildlife conflict helpline to report it.

Research from one study in Wyoming suggested that CWD was linked to an annual white-tailed deer population decline of approximately 10% during the 7-year study period (Edmunds et al. 2016). In Virginia specifically, there have not yet been population-level declines due to CWD, likely due to hunting regulation changes and management actions that keeps the disease at a lower prevalence (A. Lombard, Wildlife Health Coordinator, Virginia Department of Wildlife Resources). Assuming CWD's eventual presence in Arlington, it is unknown what effects the disease would have on the population. However, a theoretical 10% decline in the annual Arlington deer population may not be enough to immediately curb threats to plant and tree regeneration on DPR lands without other management intervention. DWR's CWD management plan for Virginia (Virginia Department of Wildlife Resources 2024) is a resource for the reader to learn more about this disease.

Hemorrhagic disease (HD).- Seasonal mortality events due to hemorrhagic disease (HD) have caused localized population declines in Virginia in some years, and any declines that may occur due to HD are considered when determining a county's upcoming hunting season regulations (A. Lombard, Wildlife Health Coordinator, Virginia Department of Wildlife Resources). However, it is difficult to predict how HD would affect future Arlington deer populations.

Management Implications

Overall, the results from browse survey efforts presented here do not bode well for the future forest health of Arlington's parks. Moderate browsing was observed at most sites, with some sites experiencing heavy browsing and few with minor browsing. Primary stewardship goals for Arlington natural lands continue to be conservation and preservation of existing natural resources, with a special emphasis on NRCAs. Recent deer population and browse impact surveys demonstrate that these goals are not being met. If deer population trajectories are left unchecked, browse rates may become heavier in the future, requiring more invasive and expensive solutions. However, Arlington is still in a better position to be proactive with deer management when compared to some adjacent jurisdictions. Deer management today would help prevent Arlington from progressing into the "severe" browsing category and would impact fewer deer needing to be managed. Moreover, vegetation that is still present could better recover in most places without extensive restoration. Without active deer management and some restoration efforts, however, the ecological health of Arlington County's natural areas will continue to degrade. Even if deer numbers and associated impacts were reduced in the short term, years or decades may be needed for plant community recovery due to the legacy effects of overbrowsing (Webster et al. 2005, Royo et al. 2010, Nuttle et al. 2014). In some areas, deer browsing that has already occurred may require replanting and protection if native plant species are to be restored to a previous natural state (Curtis 2020). Our recommendation for sharpshooting employs immediate effects to help reverse previous and ongoing browsing with the long-term goal of balancing deer populations with forest regeneration on DPR lands.

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Literature Cited

Abella, S. R., T. A. Schetter, and T. D. Gallaher. 2022. Rapid increase in sensitive indicator plants concurrent with deer management in an oak forest landscape. Wildlife Society Bulletin 46:e1377.

Anderson, R. C. 1994. Height of white-flowered trillium (*Trillium grandiflorum*) as an index of deer browsing intensity. Ecological Applications 4:104–109.

Arlington County. 2024a. Chapter 17, miscellaneous offenses and provisions, § 17-5. <https://www.arlingtonva.us/files/2062fc5b-f178-43fc-ac64-81ac57548703/Ch.-17-Miscellaneous-Offenses-and-Provisions.pdf>. Accessed 28 January 2024.

Arlington County. 2024b. Arlington County Forestry and Natural Resources Plan. <https://www.arlingtonva.us/files/sharedassets/public/v/1/environment/documents/fnrp-5.pdf>. Accessed 28 January 2024.

Arlington County Parks and Recreation. 2010. Natural Resources Management Plan. <https://www.arlingtonva.us/Government/Projects/Natural-Resources-Management-Plan>. Accessed 22 November 2022.

Arlington County Parks and Recreation. 2011. Wildlife of Arlington: A natural heritage resource inventory technical report. <https://www.arlingtonva.us/files/sharedassets/public/Projects/Documents/Wildlife-of-Arlington-A-Natural-Resource-Heritage-Technical-Report.pdf>. Accessed 6 January 2023.

Arlington County Sustainability and Environment. 2023. Stormwater and watersheds. <https://www.arlingtonva.us/Government/Programs/Sustainability-and-Environment/Stormwater/Stormwater-Watersheds#:~:text=Approximately%2042%20percent%20of%20the,to%20soak%20into%20the%20ground>. Accessed 18 February 2023.

Arnold, J., and J. M. Welch. 1996. Deer browse in the interior forest of Warwick County Park. Middle States Geographer 29:139–146.

Aukema, J. E., D. G. McCullough, B. Von Holle, A. M. Liebhold, K. Britton, and S. J. Frankel. 2010. Historical accumulation of nonindigenous forest pests in the continental United States. BioScience 60:886–897.

Bastin, J. F., Y. Finegold, C. Garcia, D. Mollicone, M. Rezende, D. Routh, C. M. Zohner, and T. W. Crowther. 2019. The global tree restoration potential. Science 365:76–79.

Beaver, J. T., R. W. Baldwin, M. Messinger, C. H. Newbolt, S. S. Ditchkoff, and M. R. Silman. 2020. Evaluating the use of drones equipped with thermal sensors as an effective method for estimating wildlife. Wildlife Society Bulletin 44:434–443.

Belant, J. L., T. W. Seamans, and C. P. Dwyer. 1998. Cattle guards reduce white-tailed deer crossings through fence openings. International Journal of Pest Management 44:247–249.

Beringer, J., L. P. Hansen, J. A. Demand, J. Sartwell, M. Wallendorf, and R. Mange. 2002. Efficacy of translocation to control urban deer in Missouri: costs, efficiency, and outcome. Wildlife Society Bulletin 30:767–774.

Bissonette, J. A., C. A. Kassar, and L. J. Cook. 2008. Assessment of costs associated with deer-vehicle collisions: human death and injury, vehicle damage, and deer loss. Human-Wildlife Conflicts 2:17–27.

Blossey, B., P. D. Curtis, J. R. Boulanger, and A. Davalos. 2019. Red oak seedlings as bioindicators to assess browsing pressure and efficacy of white-tailed deer management. Ecology and Evolution 9:13085–13103.

Boulanger, J. R., and P. D. Curtis. 2016. Efficacy of surgical sterilization for managing overabundant suburban white-tailed deer. Wildlife Society Bulletin 40:727–735.

Boulanger, J. R., P. D. Curtis, E. G. Cooch, and A. J. DeNicola. 2012. Sterilization as an alternative deer control technique: a review. Human-Wildlife Interactions 6:273–282.

Boulanger, J. R., P. D. Curtis, and B. Blossey. 2014. An integrated approach for managing white-tailed deer in suburban environments: the Cornell University study. Cornell Cooperative Extension Information Bulletin, N.Y. State College of Agriculture and Life Science, Cornell University, Ithaca, New York, USA. 32 pp.

Bragina, E. V., R. Kays, A. Hody, C. E. Moorman, C. S. DePerno, and L. S. Mills. 2019. Effects on white-tailed deer following eastern coyote colonization. Journal of Wildlife Management 83:916–924.

Briscoe, O. 2019. Deer hunting in Prince William Public parks enters second phase. Potomac Local News. <www.potomaclocal.com/2019/01/03/deer-hunting-in-prince-william-public-parks-enters-second-phase/>. Accessed 31 January 2023.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling. Oxford University Press, New York, New York, USA. 432 pp.

Chips, M. J., E. H. Yerger, A. Hervanek, T. Nuttle, A. A. Royo, J. N. Pruitt, T. P. McGlynn, C. L. Riggall, and W. P. Carson. 2015. The indirect impact of long-term overbrowsing on insects in the Allegheny National Forest region of Pennsylvania. Northeastern Naturalist 22:782–797.

City of Rockville. 2021. Fact sheet on a potential zoning text amendment to require parkland dedication or fee-in-lieu of dedication in new development and a potential parks impact fee in Rockville. Rockville, Maryland, USA.

Connors, J. P., and A. S. Gianotti. 2021. Becoming killable: white-tailed deer management and the production of overabundance in the Blue Hills. Urban Geography DOI: 10.1080/02723638.2021.1902685.

Conover, M. R. 1995. What is the urban deer problem and where did it come from? Pages 11–18 *in* J. B. McAninch, editor. Urban deer: a manageable resource? Proceedings of the 1993 Symposium of the North Central Section, The Wildlife Society, St. Louis, Missouri, USA.

Côté, S. D., T. P. Rooney, J. P. Tremblay, C. Dussault, and D. M. Waller. 2004. Ecological impacts of deer overabundance. Annual Review of Ecology Evolution and Systematics 35:113–147.

Craven, S. R., and S. E. Hygnstrom. 1994. Deer. Pages D25–40 *in* S. E. Hygnstrom, R. M. Timm, and G. E. Larson, editors. Prevention and Control of Wildlife Damage. University of Nebraska Cooperative Extension, Lincoln, Nebraska, USA.

Crystal-Ornelas, R., J. A. Brown, R. E. Valentin, C. Beardsley, and J. L. Lockwood. 2021. Meta-analysis shows that overabundant deer (Cervidae) populations consistently decrease average population abundance and species richness of forest birds. Ornithological Applications 123:1–15.

Curtis, P. D. 2020. After decades of suburban deer research and management in the eastern United States: where do we go from here? Human-Wildlife Interactions 14:111–128.

Curtis, P. D., B. Bazartseren, P. M. Mattison, and J. R. Boulanger. 2009. Estimating deer abundance in suburban areas with infrared-triggered cameras. Human–Wildlife Conflicts 3:116–128.

Curtis, P. D., and J. R. Boulanger. 2010. Relative effectiveness of repellents for preventing deer damage to Japanese yews. HortTechnology 20:730–734.

deCalesta, D. S. 1994. Impact of white-tailed deer on songbirds within managed forests in Pennsylvania. Journal of Wildlife Management 58:711–718.

deCalesta, D. S., and S. S. Stout. 1997. Relative deer density and sustainability: a conceptual framework for integrating deer management with ecosystem management. Wildlife Society Bulletin 25:252–258.

Delisle, Z. J., P. G. McGovern, B. G. Dillman, C. J. Reeling, J. N. Caudell, and R. K. Swihart. 2023. Using cost-effectiveness analysis to compare density-estimation methods for large-scale wildlife management. Wildlife Society Bulletin 47:e1430.

DeNicola, A. J., K. C. VerCauteren, P. D. Curtis, and S. E. Hygnstrom.. 2000. Managing white-tailed deer in suburban environments. Cornell University Cooperative Extension, Ithaca, New York, USA.

DeNicola, A. J., and V. L. DeNicola. 2021. Ovariectomy as a management technique for suburban deer populations. Wildlife Society Bulletin 45:445–455.

DeNicola, A. J., and S. C. Williams. 2008. Sharpshooting suburban white-tailed deer reduces deer–vehicle collisions. Human–Wildlife Conflicts 2:28–33.

Ditchkoff, S. S., S. T. Saalfied, and C. J. Gibson. 2006. Animal behavior in urban ecosystems: modifications due to human-induced stress. Urban Ecosystems 9:5–12.

Downing, R. L. 1980. Vital statistics of animal populations. Pages 247–267 in S. D. Schemnitz, editor. Wildlife management techniques manual. Fourth edition. The Wildlife Society, Washington, D.C., USA. 86 pp.

Drake, D., M. Lock, and J. Kelly. 2002. Managing New Jersey's Deer Population. Rutgers Agricultural Experiment Station, Rutgers University Press, New Brunswick, New Jersey, USA.

Duguay, J. P., and C. Farfaras. 2011. Overabundant suburban deer, invertebrates, and the spread of an invasive exotic plant. Wildlife Society Bulletin. 35:243–251.

Edmunds, D. R., M. J. Kauffman, B. A. Schumaker, F. G. Lindzey, W. E. Cook, T. J. Kreeger, R. G. Grogan, and T. E. Cornish. 2016. Chronic Wasting Disease drives population decline of white-tailed deer. PLoS ONE 11: 0161127.

Eschtruth, A. K., and J. J. Battles. 2009. Acceleration of exotic plant invasion in a forested ecosystem by a generalist herbivore. Conservation Biology 23:388–399.

Etter D. R., K. M. Hollis, T. R. VanDeelen, D. R. Ludwig, and J. E. Chelsvig. 2002. Survival and movements of white-tailed deer in suburban Chicago, Illinois. Journal of Wildlife Management 66:500–510.

Fairfax County Environmental Quality Advisory Council (EQAC). 2019. 2019 Annual Report on the Environment. Fairfax County, Virginia, USA.

Fairfax County Deer Management Program. 2023. Harvest Totals (Fiscal Years 1998–2023). < https://www.fairfaxcounty.gov/wildlife/deer-management-program>. Accessed 22 February 2024.

Federal Aviation Administration. 2016. National Part 139 CertAlert. <https://www.faa.gov/sites/faa.gov/files/airports/airport_safety/wildlife/resources/part-139-cert-alert-16-03.pdf.> Accessed 7 January 2024.

Forsyth, D. M., S. Comte, N. E. Davis, A. J. Bengsen, S. D. Côté, D. G. Hewitt, N. Morellet, and A. Mysterud. 2022. Methodology matters when estimating deer abundance: a global systematic review and recommendations for improvements. Journal of Wildlife Management 86:e22207.

Gilman, R. T., N. E. Mathews, B. G. Skinner, V. L. Julis, E. S. Frank, and J. Paul-Murphy. 2010. Effects of maternal status on the movement and mortality of sterilized female white-tailed deer. Journal of Wildlife Management 74:1484–1491.

Gionfriddo, J. P., A. J. DeNicola, L. A. Miller, and K. A. Fagerstone. 2011. Efficacy of GnRH immunocontraception of wild white-tailed deer in New Jersey. Wildlife Society Bulletin 35:142–148.

Gorsira, B., C. R. Rossell Jr., and S. Patch. 2005. Effects of white-tailed deer on vegetation structure and woody seedling composition at Manassas National Battlefield Park, Virginia. Park Science 24:Summer 2006.

Hatfield, J. S. 2005 Analysis of long-term vegetation data collected at Rock Creek Park during 1991–2003. Unpublished report. U.S. Department of Interior, National Park Service.

Horsley, S. B., S. L. Stout, and D. S. deCalesta. 2003. White-tailed deer impact on the vegetation dynamics of a northern hardwood forest. Ecological Applications 13:98–118.

Howard County Deer Task Force.1999. The Howard County deer task force report. Howard County, Maryland, USA.

Howard County Department of Recreation & Parks. 2002. Howard County Department of Recreation and Parks comprehensive deer management plan. Howard County, Maryland, USA.

Howard County Department of Recreation & Parks. 2019. Department of Recreation & Parks announces deer management program for 2019–2020. <www.howardcountymd.gov/recreation-parks/department-recreation-parks-announces-deer-management-operations-february-march>. Accessed 12 January 2023.

Hygnstrom, S. E., G. W. Garabrandt, and K. C. VerCauteren. 2011. Fifteen years of urban deer management: the Fontenelle Forest experience. Wildlife Society Bulletin 35:126–136.

Jacobson, H. A., J. C. Kroll, R. W. Browning, B. H. Koerth, and M. H. Conway. 1997. Infrared-triggered cameras for censusing white-tailed deer. Wildlife Society Bulletin 25:547–556.

Kelly, J. F. 2019. Regional changes to forest understories since the midtwentieth century: Effects of overabundant deer and other factors in northern New Jersey. Forest Ecology and Management 444:151–162.

Kilpatrick H. J, A. M. Labonte, and J. S. Barclay. 2011. Effects of landscape and land-ownership patterns on deer movements in a suburban community. Wildlife Society Bulletin 35:227–234.

Kilpatrick, H. J., A. M. LaBonte, and K. C. Stafford, III. 2014. The relationship between deer density, tick abundance, and human cases of Lyme disease in a residential community. Journal of Medical Entomology 51:777–784.

Kraft L. S., T. R. Crow, D. S. Buckley, E. A. Nauertz, and J. C. Zasada. 2004. Effects of harvesting and deer browsing on attributes of understory plants in northern hardwood forests, Upper Michigan, USA. Forest Ecology and Management 199:219–230.

Krafft, C. C., and J. S. Hatfield. 2011. Impacts of deer herbivory on vegetation in Rock Creek Park, 2001–2009. Natural Resource Technical Report NPS/NCR/NCRO/NRTR–2011/001. United States Department of the Interior, National Park Service, Washington, D.C., USA.

Krafft, C. C., and J. S. Hatfield. 2015. Impacts of deer herbivory on vegetation in Rock Creek Park, 2001–2014. Natural Resource Report NPS/NCRO/NRR–2015/001. National Park Service, Fort Collins, Colorado, USA.

Leong, K. M. 2009. The tragedy of becoming common: landscape change and perceptions of wildlife. Society & Natural Resources 23:111–127.

Liebhold, A. M., D. G. McCullough, L. M. Blackburn, S. J. Frankel, B. Von Holle, and J. E. Aukema, 2013. A highly aggregated geographical distribution of forest pest invasions in the USA. Diversity and Distributions 19:1208–1216.

Long, R. P., P. H. Brose, and S. B. Horsley. 2012. Responses of northern red oak seedlings to lime and deer exclosure fencing in Pennsylvania. Canadian Journal of Forest Research 42:698–709.

MacLean, R. A., N. E. Mathews, D. M. Grove, E. S. Frank, and J. Paul-Murphy. 2006. Surgical technique for tubal ligation in white-tailed deer (*Odocoileus virginianus*). Journal of Zoo and Wildlife Medicine 37:354–360.

Masters, K. 2019. Rockville takes aim at growing deer population: new pilot program allows archery for herd management. Bethesda Magazine. 17 December 2019.

McWilliams, W. H., J. A. Westfall, P. H. Brose, D. C. Dey, A. W. D'Amato, Y. L. Dickinson, M. A. Fajvan, L. S. Kenefic, C. C. Kern, K. M. Laustsen, S. L. Lehman, R. S. Morin, T. E. Ristau, A. A. Royo, A. M. Stoltman, and S. L. Stout. 2018. Subcontinental-scale patterns of large-ungulate herbivory and synoptic review of restoration management implications for Midwestern and Northeastern Forests. Gen. Tech. Rep. NRS-182. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station, Newton Square, Pennsylvania, USA.

McShea, W. J. 2012. Ecology and management of white-tailed deer in a changing world. Annals of the New York Academy of Sciences 1249:45–56.

McShea, W. J., and N. A. Bourg. 2009. The assessment of impacts of white-tailed deer foraging on woodlots in the Chesapeake and Ohio Canal National Historical Park and the Antietam and Monocacy National Battlefields. Front Royal, VA Smithsonian Institution National Zoological Park Conservation and Research Center.

McShea, W. J., N. A. Bourg, D. Rowan, and S. Serchan. 2010. The assessment of impacts of white-tailed deer foraging on woodlots in the Manassas National Battlefield Park. Front Royal, VA, Smithsonian Conservation Biology Institute at the National Zoo.

Miller, K. M., and B. J. McGill. 2019. Compounding human stressors cause major regeneration debt in over half of eastern US forests. Journal of Applied Ecology 56:1355–1366.

Montgomery County. 2022. Deer in Montgomery County. <montgomeryparks.org/deer-management/>. Accessed 10 January 2023.

Montgomery County Deer Management Work Group. 1995. Comprehensive management plan for white-tailed deer in Montgomery County, Maryland: goals, objectives, implementation. Montgomery County, Maryland, USA.

Montgomery County Deer Management Work Group. 2015. Montgomery County deer management program annual report and recommendations fiscal year 2015. Montgomery County, Maryland, USA.

Morey, P. S., E. M. Gese, and S. D. Gehrt. 2007. Spatial and temporal variation in the diet of coyotes in the Chicago metropolitan area. American Midland Naturalist 158:147–161.

National Park Service. 2011. Final Rock Creek Park white-tailed deer management plan/environmental impact statement. U.S. Department of the Interior, Washington, D.C., USA.

National Park Service. 2012. Rock Creek Park Deer Management Plan. <www.foresthillsconnection.com/site2/wp-content/upLoadImage2012/Rock-Creek-Deer-Management-Plan.pdf>. Accessed 7 February 2023.

National Park Service. 2014a. Final white-tailed deer management plan and environmental impact statement: Antietam National Battlefield, Monocacy National Battlefield, and Manassas National Battlefield Park, Maryland and Virginia. U.S. Department of the Interior, Washington, D.C., USA.

National Park Service. 2014b. “National Park Service Approves Battlefield White-Tailed Deer Management Plan”. Press release, September 25, 2014. <www.nps.gov/mana/learn/news/national-park-service-approves-battlefield-white-tailed-deer-management-plan.htm>. Accessed 9 January 2023.

National Park Service. 2017. White-tailed deer management plan and environmental assessment: Chesapeake and Ohio Canal and Harpers Ferry National Historical Parks. Washington, D.C., USA.

National Park Service. 2018a. Manassas National Battlefield Park will begin deer management operations in 2019. NPS news release, 19 December 2018. <www.nps.gov/mana/learn/news/manassas-national-battlefield-park-will-begin-deer-management-operations-in-2019.htm>. Accessed 9 January 2023.

National Park Service. 2018b. Finding of No Significant Impact, White-tailed Deer Management Plan and Environmental Assessment Chesapeake and Ohio Canal and Harpers Ferry National Historical Parks, Maryland, Virginia, West Virginia. Washington, D.C., USA.

National Park Service. 2021. White-tailed deer management plan and environmental assessment. National Capital Parks – East. National Capital Parks – East, Washington, D.C., USA.

National Park Service. 2022. White-tailed deer management. <https://www.nps.gov/rocr/learn/management/white-tailed-deer-management.htm>. Accessed 12 January 2023.

National Park Service. 2024. National Capital Parks – East deer management. <https://www.nps.gov/nace/learn/management/deer-management.htm>. Accessed 28 January 2024.

New York City Parks & Recreation. 2024. Managing deer impacts on Staten Island. <https://storymaps.arcgis.com/stories/d6fb0f6135a2496080607b3307bc4f20>. Accessed 28 January 2024.

Nielsen, D. G., M. J. Dunlap, and K. V. Miller. 1982. Pre-rut rubbing by white-tailed bucks: nursery damage, social role, and management options. Wildlife Society Bulletin 10:341–348.

Ng, J. W., C. Nielsen, and C. C. St. Clair. 2008. Landscape and traffic factors influencing deer–vehicle collisions in an urban environment. Human–Wildlife Conflicts 2:34–47.

Nuttle, T. T., T. E. Ristau, and A. A. Royo. 2014. Long-term biological legacies of herbivore density in a landscape-scale experiment: forest understoreys reflect past deer density treatments for at least 20 years. Journal of Ecology 102:221–228.

Palmer, C., H. G. Pedersen, and P. Sandøe. 2018. Beyond castration and culling: should we use non-surgical, pharmacological methods to control the sexual behavior and reproduction of animals? Journal of Agricultural and Environmental Ethics 31:197–218.

Parsons, A. W., T. Forrester, W. J. McShea, M. C. Baker-Whatton, J. J. Millspaugh, and R. Kays. 2017. Do occupancy or detection rates from camera traps reflect deer density? Journal of Mammalogy 98:1547–1557.

Pierson, T. G., and D. deCalesta. 2015. Methodology for estimating deer browsing impact. Human-Wildlife Interactions 9:67–77.

Porter, W. F. 1991. White-tailed deer in eastern ecosystems: implications for management and research in National Parks. Natural Resources Report NPS/NRSUNY/NRR-91/05. Washington, D.C., USA.

Potratz, E. J., J. S. Brown, T. Gallo, C. Anchor, and R. M. Santymire. 2019. Effects of demography and urbanization on stress and body condition in urban white-tailed deer. Urban Ecosystems 22:807–816.

Prince George's County. 2022. Deer management. <https://www.pgparks.com/529/Deer-Management>. Accessed 10 January 2023.

Putman, R., P. Watson, and J. Langbein. 2011. Assessing deer densities and impacts at the appropriate level for management: a review of methodologies for use beyond the site scale. Mammal Review 41:197–219.

Quirion, B. R. 2022. The utility of four protocols for assessing white-tailed deer browsing severity as indicators of ecological change: the need for validation and accountability. Thesis, Cornell University, Ithaca, New York, USA.

Quirion, B. R., and B. Blossey. 2023. Experimental evaluation of four protocols for assessing white-tailed deer browse intensity. Ecological Indicators 154:110651.

Raizman, E. A., J. D. Holland, and J. T. Shukle. 2013. White-tailed deer (*Odocoileus virginianus*) as a potential sentinel for human Lyme disease in Indiana. Zoonoses and Public Health 60:227–233.

Rawinski, T. J. 2014. White-tailed deer in Northeastern forests: understanding and assessing impacts. Gen. Tech. Rep. NA-IN-02-14, Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area State and Private Forestry.

Rawinski, T. J. 2018. Monitoring white-tailed deer impacts: the ten-tallest method (draft). U.S. Department of Agriculture, Forest Service, Newtown Square, Pennsylvania, USA. <https://flnps.org/sites/default/files/newsletters/Ten-tallest%20Method%20Instructions%202018.pdf>. Accessed 15 October 2022.

Roelle, J. E., S. S. Germaine, A. J. Kane, and B. S. Cade. 2017. Efficacy of SpayVac as a contraceptive in feral horses. Wildlife Society Bulletin 41:107–115.

Romin, L. A., and J. A. Bissonette. 1996. Deer-vehicle collisions: status of state monitoring activities and mitigation efforts. Wildlife Society Bulletin 24:276–283.

Rooney, T. P., and D. M. Waller. 2003. Direct and indirect effects of white-tailed deer in forest ecosystems. Forest Ecology and Management 181:165–176.

Rossell, Jr., C. R., S. Patch, and S. Salmons. 2007. Effects of deer browsing on native and non-native vegetation in a mixed oak-beech forest on the Atlantic Coastal Plain. Northeastern Naturalist 14:61–72.

Royo, A. A, D. W. Kramer, K. V. Miller, N. P. Nibbelink, and S. L. Stout. 2016. The canary in the coal mine: sprouts as a rapid indicator of browse impact in managed forests. Ecological Indicators 69:269–275.

Royo, A. A., S. L. Stout, D. S. deCalesta, and T. G. Pierson. 2010. Restoring forest herb communities through landscape-level deer herd reductions: is recovery limited by legacy effects? Biological Conservation 143:2425–2434.

Rutberg A. T., R. E. Naugle, J. W. Turner, Jr., M. A. Fraker, and D. R. Flanagan. 2013a. Field testing of single-administration porcine zona pellucida contraceptive vaccines in white-tailed deer (*Odocoileus virginianus*). Wildlife Research 40:281–288.

Rutberg A. T., R. E. Naugle, and F. Verret. 2013b. Single-treatment porcine zona pellucida immunocontraception associated with reduction of a population of white-tailed deer (*Odocoileus virginianus*). Journal of Zoo and Wildlife Medicine 44:75–83.

Rutberg, A. T., and K. Pereira. 2021. White-tailed deer contraception and impact study Village of Hastings-on-Hudson, New York. 2020 Report to the New York State Department of Environmental Conservation, Albany, New York, USA. 15 pp.

Schweitzer, D., J. R. Garris, A. E. McBride, and J. A. M. Smith. 2014. The current status of forest Macrolepidoptera in northern New Jersey: evidence for the decline of understory specialists. Journal of Insect Conservation 18:561–571.

Sterba, J. 2012. Nature wars; the incredible story how wildlife comebacks turned backyards into battlegrounds. Crown Publishers, New York, New York, USA.

Steward Green™. 2021. White-tailed deer (*Odocoileus virginianus*) population density survey using sUAS infrared: Arlington County, Virginia - Spring 2021. Final report to Arlington County Parks and Recreation, Arlington, Virginia, USA.

Swihart, R, P. Picone, A. DeNicola, and L. Cornicelli. 1995. Ecology of urban and suburban white-tailed deer. Pages 35–44 in J. B. McAninch, editor. Urban deer: a manageable resource? Proceedings of the 1993 Symposium of the North Central Section, The Wildlife Society, 12–14 December 1993, St. Louis, Missouri, USA.

Thomas, L., S. T. Buckland, E. A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R. B. Bishop, T. A. Marques, and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology 47:5–14.

Tilghman, N. G. 1989. Impacts of white-tailed deer on forest regeneration in northwestern Pennsylvania. Journal of Wildlife Management 53:524–532.

U.S. Centers for Disease Control and Prevention. 2024. <https://www.cdc.gov/lyme/data-research/facts-stats/lyme-disease-case-map.html>. Accessed 29 May 2024.

VanClef, M. 2022. Forest Health Monitoring Protocols. <http://www.njecologicalsolutions.com/forestMonitoring.html>. Accessed 12 January 2023.

VerCauteren, K. C., M. J. Lavelle, and S. Hygnstrom. 2010. Fences and deer damage management: a review of designs and efficacy. Wildlife Society Bulletin 34:191–200.

Virginia Department of Health. 2024. Ticks and tick-borne diseases of Virginia. <https://www.vdh.virginia.gov/content/uploads/sites/217/2023/07/Ticks-and-Tick-borne-Disease-in-Virginia-Flyer.pdf>. Accessed 28 January 2024.

Virginia Department of Transportation. 2024. Traffic crashes. <https://dashboard.virginiadot.org/Pages/Safety/Crashes.aspx>. Accessed 30 May 2024.

Virginia Department of Wildlife Resources. 2024. 2021–2025 chronic wasting disease management plan. <https://dwr.virginia.gov/wp-content/uploads/media/2021-2025-DWR-CWD-Plan-FINAL.pdf>. Accessed 15 January 2024. Accessed 15 January 2024.

Virginia Law Portal. 2024. Code of Virginia accident reports. <https://law.lis.virginia.gov/vacodefull/title46.2/chapter3/article11/>. Accessed 30 May 2024.

Walker, M. J., G. C. Shank, M. K. Stoskopf, L. J. Minter, and C. S. DePerno. 2021. Efficacy and cost of GonaCon™ for population control in a free-ranging white-tailed deer population. Wildlife Society Bulletin 45:589–596.

Waller, D. M. 2018. From twig to tree: simple methods for teachers and students to track deer impacts. American Journal of Botany 105:625–627.

Waller, D. M., and S. Alverson. 1997. The white-tailed deer: a keystone herbivore. Wildlife Society Bulletin 25:317–226.

Webster, C. R., M. A. Jenkins, and J. H. Rock. 2005. Long-term response of spring flora to chronic herbivory and deer exclusion in Great Smoky Mountains National Park, USA. Biological Conservation 125:297–307.

Weckel, M., R. F. Rockwell, and F. Secret. 2011. A modification of Jacobson et al.'s (1997) individual branch-antlered male method for censusing white-tailed deer. Wildlife Society Bulletin 35:445–451.

White-Tailed Deer Task Force. 2012. City of Rockville white-tailed deer management plan. City of Rockville, Maryland, USA.

Williams C. E., E. V. Mosbacher, and W. J. Moriarity. 2000. Use of turtlehead (*Chelone glabra* L.) and other herbaceous plants to assess intensity of white-tailed deer browsing on Allegheny Plateau riparian forests, USA. Biological Conservation 92:207–215.

Williams, S. C., A. J. DeNicola, T. Almendinger, and J. Maddock. 2013. Evaluation of organized hunting as a management technique for overabundant white-tailed deer in suburban landscapes. Wildlife Society Bulletin 37:137–145.

Yang, J., Z. Zhou, G. Li, Z. Dong, Q. Li, K. Fu, H. Liu, Z Zhong, H. Fu, Z. Ren, W. Gu, and G. Peng. 2023. Oral immunocontraceptive vaccines: a novel approach to fertility control in wildlife. American Journal of Reproductive Immunology 89:e13653.

Appendices

Appendix A – White-tailed Deer in Arlington County, Virginia: Herbivory Impacts in County Parks

Submitted to:
Arlington County Parks & Recreation

December 2022

Thomas J. Rawinski

ARLINGTON
VIRGINIA

Executive Summary

Nine properties within the Arlington County Park System (Barcroft, Benjamin Banneker, Bluemont, Bluemont Junction, Bon Air, Donaldson Run, Glencarlyn, Gulf Branch, and Windy Run Parks) were assessed for the impact of deer browse on the understory vegetation within forested areas. We used USDA Forest Service's ten-tallest method for these surveys. The ten-tallest individuals in the population sample are measured for height and evaluated for evidence of browse damage. This method evaluates plant *populations*, and repeated sampling captures height growth over time, a critical metric when evaluating deer impact.

In all, 22 plot centers were established and 31 plant populations were sampled. These populations were comprised of 13 species, some of which were sampled at multiple sites. Overall, 88% of all stems examined across Arlington exhibited browse damage by deer. By species, assessed browsing ranged from 100% of chestnut oak (*Quercus prinus*), strawberry bush (*Euonymus americanus*), winged euonymus (*Euonymus alatus*), catalpa (*Catalpa speciosa*), and black cherry (*Prunus serotina*), to a low of 10% for eastern red-cedar (*Juniperus virginiana*). The level of deer impact varied within parks, among parks, and among plant species. Preferred plant species were consistently browsed while low-preference species, such as mountain laurel (*Kalmia latifolia*), showed browse damage at Donaldson Run and Windy Run, suggesting higher browse impact in those areas. A number of plant species that are known to be avoided by deer showed no evidence of browse damage. This survey observed selective browsing by deer which could foreseeably result in plant community shifts over time; however, further controlled study is required to document such impacts.

Most park land can be assigned to the broad category of moderate impact. Criteria for high impact were met in certain areas. Low impact areas were few and far between. Tree regeneration failure was widespread. While small tree saplings may be locally plentiful, very few will be able to grow above the reach of deer. Because Arlington's deer show little fear of people, the browsers are having impacts in areas that would ordinarily be avoided by more skittish, wilder deer. Hence, deer impacts are unusually pervasive in Arlington.

Methodology

During the week of October 2, 2022, plot-based vegetation sampling was conducted at the locations identified during reconnaissance (Figs. 1–6). The sampling utilized the USDA Forest Service's ten-tallest method (Rawinski 2018). The ten tallest individuals in the population sample are measured for height and evaluated for evidence of browse damage. This novel method evaluates plant *populations*, and repeated sampling captures height growth over time, a critical metric when evaluating deer impact. A criterion for plot selection is that the plot area must contain a population sample of at least 10 individuals. This helps ensure that site conditions are favorable to the species. A plot area may contain multiple species. While an individual plant may be browsed by deer without negative consequences, this method looks at whether or not the overall population is resilient to overcoming these individual impacts.

A circular 0.01-hectare plot (18.5 ft. radius) is established where at least 10 individuals of a species are found. PVC stakes mark the plot centers and GPS coordinates are recorded. A two-meter-tall density rod is photographed at plot centers. Once ten plants within the plot have been measured for height, a search for any taller plants is conducted. If found, the new taller measurement replaces the shorter measurement. The process is repeated until there is confidence that the ten tallest individuals have been measured. These ten tallest individuals in the population sample are evaluated for evidence of browse damage. Where appropriate, the number of reproductive stems in the population sample is recorded as well (Appendix A1).

Results and Discussion

In all, 22 plot centers were established and 31 plant populations were sampled. These populations were comprised of 13 species, some of which were sampled at multiple sites. Overall, 88% of the stems examined across Arlington exhibited browse damage by deer. By species, 100% of assessed chestnut oak (*Quercus prinus*), strawberry bush (*Euonymus americanus*), winged euonymus (*Euonymus alatus*), catalpa (*Catalpa speciosa*), and black cherry (*Prunus serotina*) stems were browsed. In descending order, other species assessed with percent of stems browsed included: white oak (*Quercus alba*) (95%), tulip tree (*Liriodendron tulipifera*)(95%), white ash (*Fraxinus americana*)(90%), maple-leaf viburnum (*Viburnum acerifolium*)(89%), spicebush (*Lindera benzoin*)(83%), ironwood (*Ostrya virginiana*)(80%), boxelder (*Acer negundo*)(20%), and eastern red-cedar (*Juniperus virginiana*)(10%). Data from population samples are presented as worksheets in a single Microsoft Excel document that was provided to DPR.

Plot centers are shown in Figs. 7–28. If one omits the meadow vegetation shown in Figs. 7 and 14, most of the other photographs reveal sparse understory vegetation and simple forest structure. To the trained eye, such conditions are diagnostic of prolonged deer impact. Figs. 22 and 25 are exceptions because they show relatively lush understory vegetation. The Glencarlyn 3 plot (Fig. 22) is bordered on three sides by well-used hiking trails. The deer are apparently avoiding this high use recreational area. The lush understory of Glencarlyn 6 plot (Fig. 25) is difficult to explain. Some trees had been recently cut, which increased light to the understory. The deer did browse stump sprouts of red maple (*Acer rubrum*) and red oak (*Quercus rubra*) at this location, but other preferred species, including flowering dogwood (*Benthamidia florida*), remained unbrowsed. Deer impacts across a landscape are never uniform (Rawinski 2014).

Barcroft Park

Stake no.	Species	Avg. Height (in)	Percent Browsed
Barcroft 1	Spicebush	29.75	100
Barcroft 2	Chestnut Oak	25.40	100

All (100%) of the assessed stems at Barcroft Park were browsed. The spicebush at Barcroft 1 was being suppressed by deer browsing (Fig. 29), as was co-occurring common greenbrier (*Smilax rotundifolia*). The white snakeroot (*Ageratina altissima*) in the plot was avoided by deer (Fig. 30) as were slender woodoats (*Chasmanthium laxum*), which grew nearby. Nearby saplings of sweetbay magnolia (*Magnolia virginiana*) showed no browse damage (Fig. 31). Evidence of browsing on chestnut oak was largely determined by deformed/crooked stem growth. An example of chestnut oak is depicted in Fig. 32.

Benjamin Banneker Park

Stake no.	Species	Avg. Height (in)	Percent Browsed
Banneker 1	Catalpa	29.75	100

All (100%) of the assessed stems at Benjamin Banneker Park were browsed. The catalpas at Banneker 1 are only a few years old but exhibited browsing (Fig. 33). They colonized an area disturbed by bamboo removal. The catalpas growing about 50 meters away showed virtually no browse damage. It is suspected that the catalpas at Banneker 1 grew near a deer movement corridor. The spotted touch-me-nots (*Impatiens capensis*) here, as elsewhere, showed considerable browse damage. Turk's cap lily (*Lilium superbum*) once grew in the adjacent wetland but has not been seen for years (A. Abugattas, DPR, personal communication).

Bluemont Park

Stake no.	Species	Avg. Height (in)	Percent Browsed
Bluemont 1	Ironwood	13.15	80
Bluemont 2	Spicebush	18.75	90

Most (85%) of the assessed stems at Bluemont Park were browsed. Barely ten individuals of ironwood occurred in the plot area, and these were relatively young (Fig. 34). The plants are affected by deer browsing and are also shaded by canopy trees and spicebush. The tall thickets of spicebush at Bluemont 2 show a browse line. The smaller plants are experiencing considerable browse damage.

Bluemont Junction Park

Stake no.	Species	Avg. Height (in)	Percent Browsed
Bluemont Junction 1	White Oak	10.75	100

All (100%) of the assessed stems at Bluemont Junction Park were browsed. Under current browse pressure, it is unlikely that the understory white oaks will be able to grow above the reach of deer. Noteworthy at Bluemont Junction 1 was Japanese honeysuckle (*Lonicera japonica*), a deer resistant species, which showed browse damage.

Bon Air Park

Stake no.	Species	Avg. Height (in)	Percent Browsed
Bon Air 1	White Ash	33.65	80

Most (80%) of the assessed stems at Bon Air Park were browsed. The white ashes at Bon Air 1 are robust individuals growing in a stiltgrass-dominated meadow. Leaf blades had been browsed on six of the eight browsed individuals (Fig. 35).

Other notes: Five deer were seen in the vicinity.

Donaldson Run Park

Stake no.	Species	Avg. Height (in)	Percent Browsed
Donaldson 1	Tulip Tree	13.70	100
Donaldson 1	Boxelder	10.30	20
Donaldson 2	Spicebush	18.25	60
Donaldson 3	Winged Euonymus	28.30	100
Donaldson 4	Strawberry Bush	13.65	100
Donaldson 4	Maple-leaf Viburnum	11.25	100*
Donaldson 5	Maple-leaf Viburnum	26.60	100
Donaldson 5	Chestnut Oak	8.65	100

* 4 plants total

Most (85%) of the assessed stems at Donaldson Run Park were browsed. Evidently, tulip tree is a preferred species because leaf blades of this species were frequently browsed. The tulip trees at Donaldson 1 were young, not much more than three years old. Tulip tree has the potential for rapid height growth when compared to other native species. This may prove to be advantageous as they would be able to grow beyond the reach of deer in a shorter period of time. Continued monitoring of this plot could show whether this hypothesis is true. Much will depend on the extent of winter browsing of terminal buds. Browse damage to tulip tree leaf blades is illustrated in Fig. 36. Boxelders grew with the tulip trees sampled at Donaldson 1 and they were approximately the same age (i.e., about three years old). Evidence at this site suggested recent clearing of Japanese stiltgrass (*Microstegium vimineum*); moreover, this site receives considerable sunlight. Only 20% of the boxelder stems showed browse damage, apparently because the stems were mostly concealed by herbaceous vegetation.

The spicebush at Donaldson 2 (Fig. 37) grows on a mesic slope with browsed Asiatic bittersweet (*Celastrus orbiculatus*). Also in the plot was Christmas fern (*Polystichum acrostichoides*). Browsing of Christmas fern is suspected and confirmation is recommended in early spring. Such browsing would indicate high deer impact. Nearby grew pawpaw (*Asimina triloba*) which is a low preference species.

Donaldson 3 is close to a major trail and a nearby private property contains large burning bushes that gave rise to hundreds of young plants in the understory. As with strawberry bush, winged euonymus is consistently browsed. The current level of browse impact to winged euonymus is preventing this invasive exotic from growing to maturity. Browsed winged euonymus at Donaldson 3 is shown in Fig. 38.

Strawberry bush is highly preferred by deer. Its green leaves remain attractive well into fall. Impacts at Donaldson 4 are typical of those observed during reconnaissance at other locations. Fig. 39 shows browse impact to strawberry bush at Donaldson 4. Caged viburnum at Donaldson 4 is depicted in Fig. 40. Normally, ten individuals must occur in a ten-tallest plot, but an exception was made for Donaldson 4 where four stems occurred in the vicinity of a caged, 38-inch tall, fruit-bearing viburnum plant. The cage protecting the viburnum plant had evidently been in place for several years.

The only fruiting stem (41 inches tall) at this park was observed on maple leaf viburnum at stake location Donaldson 5. The associated plant community at this location was relatively species-rich. White wood-aster (*Eurybia divaricata*) showed browse damage; six flowering individuals remained in the plot. Heavily browsed pinxter-flower (*Rhododendron periclymenoides*) was scarcely five inches tall. Panicled hawkweed (*Hieracium paniculatum*) showed browse damage. Other species in the plot were American holly (*Ilex opaca*), plantain-leaved pussytoes (*Antennaria plantaginifolia*) and Indian cucumber-root (*Medeola virginiana*). Chestnut oak was assessed at Donaldson 5. The population samples of chestnut oak in this study showed variability in average height. They also varied in the number of individuals present within plot areas, with Barcroft 1 having more than 100 and others not many more than 10. The number of individuals are believed to reflect varying site/growing conditions.

Other notes: Mountain laurel (*Kalmia latifolia*), a deer resistant species, at Donaldson Run presented a visible browse line.

Glencarlyn Park

Stake no.	Species	Avg. Height (in)	Percent Browsed
Glencarlyn 1	Maple-leaf Viburnum	24.05	100
Glencarlyn 2	White Oak	13.55	90
Glencarlyn 3	Strawberry Bush	22.05	100
Glencarlyn 4	Maple-leaf Viburnum	13.10	100
Glencarlyn 4	Chestnut Oak	23.40	100
Glencarlyn 5	Chestnut Oak	9.55	100
Glencarlyn 5	Black Cherry	17.70	100
Glencarlyn 6	Maple-leaf Viburnum	58.75	10
Glencarlyn 7	Maple-leaf Viburnum	38.60	100

Most (89%) of the assessed stems at Glencarlyn Park were browsed. Glencarlyn 1 lies about 10 meters from a deer exclosure that was constructed in 2022. It is recommended to measure the viburnums growing inside the fence. A benefit of Glencarlyn 1 is that it can be compared over time with the growth and fecundity of the fenced plants. The tallest viburnum stem at Glencarlyn 1 was growing among protective vines of common greenbrier, an example of associational defense. Some viburnum stems achieved as much as 20 inches of height growth during the 2022 growing season. A viburnum stem at Glencarlyn 1 suppressed by deer browsing is shown in Fig. 41.

Fig. 42 shows a white oak at Glencarlyn 2. Again, under current browse pressure, it is doubtful that the understory white oaks will be able to grow above the reach of deer.

Glencarlyn 3 is bordered on three sides by highly used walking trails. High levels of recreational use evidently limit browse impact in this and other similar areas. Strawberry bush is able to achieve full growth potential on steep-slope refugia. Glencarlyn 3 contained two fruiting strawberry bushes that had grown above the reach of deer – about seven and nine feet tall – and were, therefore, excluded from ten-tallest sampling. These tall strawberry bushes were entwined with greenbrier, another example of associational defense. A mature yew (*Taxus* sp.) in the plot had a browse line. Fig. 43 shows browse impact to strawberry bush.

A single sprout of American chestnut (*Castanea dentata*) was found near Glencarlyn 4. Examples of chestnut oak at Glencarlyn 4 and 5 are shown in Figs. 44 and 45, respectively. Excluded from the Glencarlyn 4 viburnum data is an 89-inch, fruit-bearing stem that had grown above the reach of deer. The ten-tallest method excludes such stems but records their presence. The tall stem represents a legacy effect from the period of time when deer browsing did not suppress viburnum height growth.

Glencarlyn 5 had a tall cherry sapling that was not measured because it had grown above the reach of deer. Under current browse pressure, it is doubtful that the smaller saplings will be able to do the same. Fig. 46 shows a black cherry at Glencarlyn 5.

The lush understory vegetation at Glencarlyn 6 was discussed earlier. Browse damage is limited to stump sprouts of red maple and red oak. At Glencarlyn 6, viburnum stems were tall, with many bearing fruit (Fig. 47). No browse damage was observed to highly preferred flowering dogwood (Fig. 48) and bluestem goldenrod (*Solidago caesia*)(Fig. 49).

The relatively tall viburnums at Glencarlyn 7 are misleading. These are stems that were able to grow tall before deer impact became problematic. Presently, all stems are spindly and bear few leaves. Dead stems are common among the living stems. The population trajectory is clear. The taller stems will continue to die. The few leaves are not enough to keep the stems alive.

Other notes: Early sweet blueberry (*Vaccinium pallidum*) occurs near Glencarlyn 7; because of deer browsing, its stems are about half as tall as normal.

Gulf Branch Park

Stake no.	Species	Avg. Height (in)	Percent Browsed
Gulf Branch 1	Maple-leaf Viburnum	22.75	100
Gulf Branch 1	White Ash	20.75	100

All (100%) of the assessed stems assessed at Gulf Branch Park were browsed. The viburnums at Gulf Branch 1 are typical of browsed stems found across much of the area. Noteworthy are two co-occurring heavily browsed species, winterberry (*Ilex verticillata*) and wild hydrangea (*Hydrangea arborescens*) (Fig. 50). Wild hydrangea is a highly preferred species. In Arlington, its mature stems are restricted to trail edges and the refugia of steep, inaccessible slopes. Barely ten individuals of white ash occurred at Gulf Branch. These were relatively small, shaded individuals. Past browsing caused stem deformity (Fig. 51).

Windy Run Park

Stake no.	Species	Avg. Height (in)	Percent Browsed
Windy Run 1	Maple-leaf Viburnum	27.15	100
Windy Run 1	Chestnut Oak	11.15	100
Windy Run 1	Tulip Tree	15.00	90
Windy Run 1	Black Cherry	13.95	100

Most (98%) of the assessed stems assessed at Windy Run Park were browsed. The viburnums at Windy Run were relatively tall. Chestnut currently survives in Windy Run as stump resprouts, and their susceptibility to browse may increase their risk of extirpation due to chestnut blight. Evidence of browsing was largely determined by deformed/crooked stem growth. Such stems are slow to achieve height growth. It will take many years for the stems to grow out of reach of deer browsing. However, it is unlikely that under current browse pressure any of the young chestnut oaks will be able to grow above the reach of deer. Leaf blades of tulip tree were frequently browsed. Again, tulip tree appears to be a preferred species. The tulip trees at Windy Run were young, not much more than three years old. Tulip trees have the potential for rapid height growth when compared to other native species. Deformed stem growth of black cherry was diagnostic of past browsing.

Other notes: Nearby mountain laurel bushes showed a browse line. Basal sprouts of the laurel were kept short by repeated browsing (Fig. 52). Near the Windy Run plot grew two graminoids avoided by deer, ribbed sedge (*Carex virescens*) and slender-spiked woodland sedge (*Carex digitalis*).

Fort C.F. Smith Park

Stake no.	Species	Avg. Height (in)	Percent Browsed
C.F. Smith 1	Eastern Red-cedar	38.7	10

Although Fort C.F. Smith Park was not assessed via the typical ten-tallest method, we did evaluate eastern red-cedar via the plot-less variant of the method which involved affixing numbered aluminum tags to ten plants. The tagged plants are within about 15 meters of the central PVC stake. The plants averaged 38.7 inches tall and only one individual showed browse damage. Future re-sampling will reveal whether browse impact changes. Fig. 53 shows two of the tagged red-cedars.

Conclusion

The level of deer impact varied within parks, among parks, and among plant species. Overall, 88% of all stems examined across Arlington exhibited browse damage by deer. Preferred plant species were consistently browsed while low-preference species, such as mountain laurel, showed browse damage at Donaldson Run and Windy Run, suggesting higher browse impact in those areas. A number of plant species that are known to be avoided by deer showed no evidence of browse damage. This survey observed selective browsing by deer which could foreseeably result in plant community shifts over time; however, further controlled study is required to document such impacts.

Most park land can be assigned to the broad category of moderate impact. Criteria for high impact were met in certain areas. Low impact areas were few and far between. Tree regeneration failure was widespread. While small tree saplings may be locally plentiful, very few will be able to grow above the reach of deer. Because Arlington's deer show little fear of people, the browsers are having impacts in areas that would ordinarily be avoided by more skittish, wilder deer. Hence, deer impacts are unusually pervasive in Arlington.

Literature

Rawinski, T. J. 2014. White-tailed deer in Northeastern forests: Understanding and assessing impacts. Gen. Tech. Rep. NA-IN-02-14, Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area State and Private Forestry.

Rawinski, T. J. 2018. Monitoring white-tailed deer impacts: The ten-tallest method (draft). U.S. Department of Agriculture, Forest Service, Newtown Square, Pennsylvania, USA. <https://flnps.org/sites/default/files/newsletters/Ten-tallest%20Method%20Instructions%202018.pdf>. Accessed 5 December 2022.

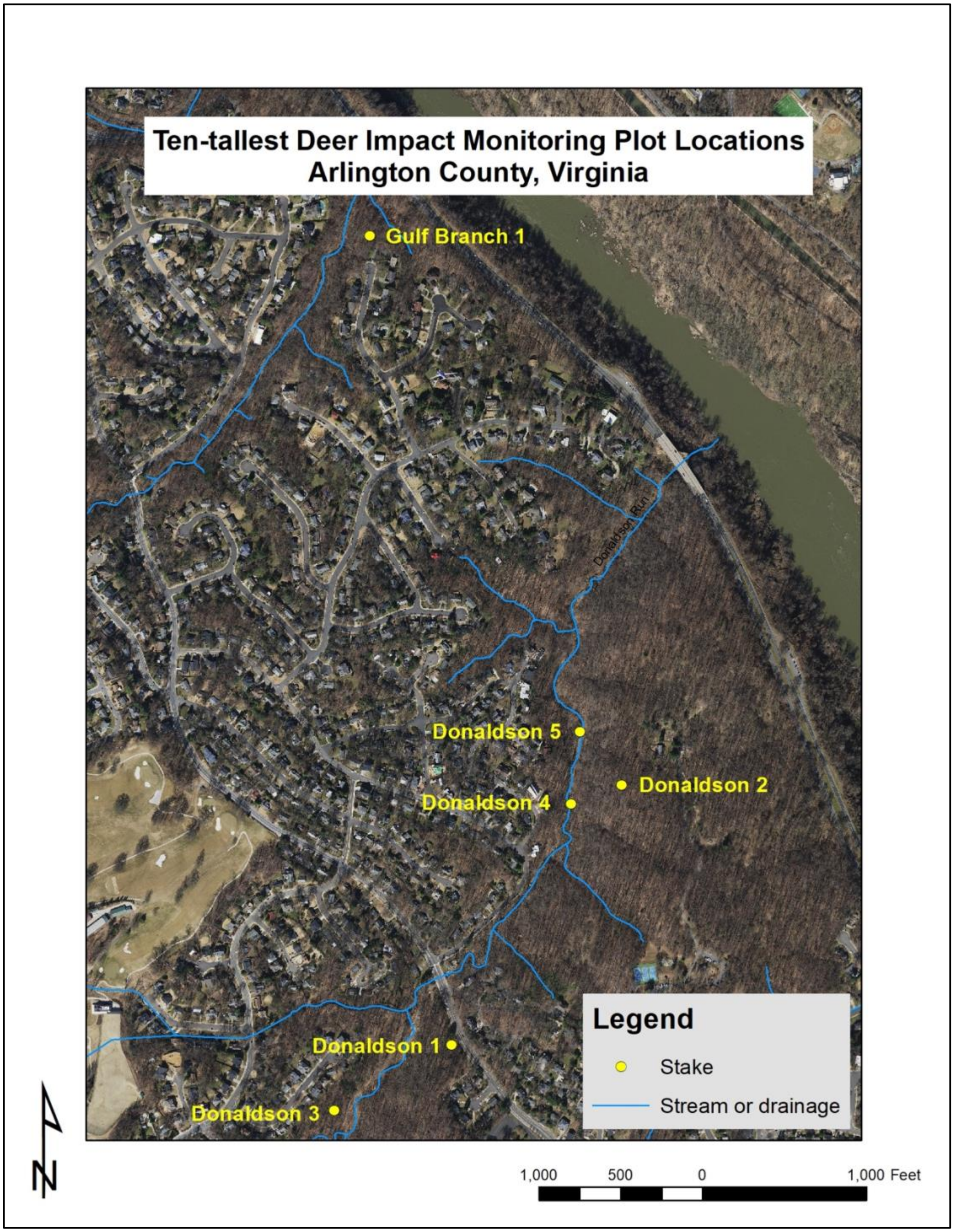


Fig. 1. Plot locations for Donaldson Run and Gulf Branch Parks.

Fig. 2. Plot locations for Fort C. F. Smith and Windy Run Parks.

Fig. 3. Plot locations for Glencarlyn Park.

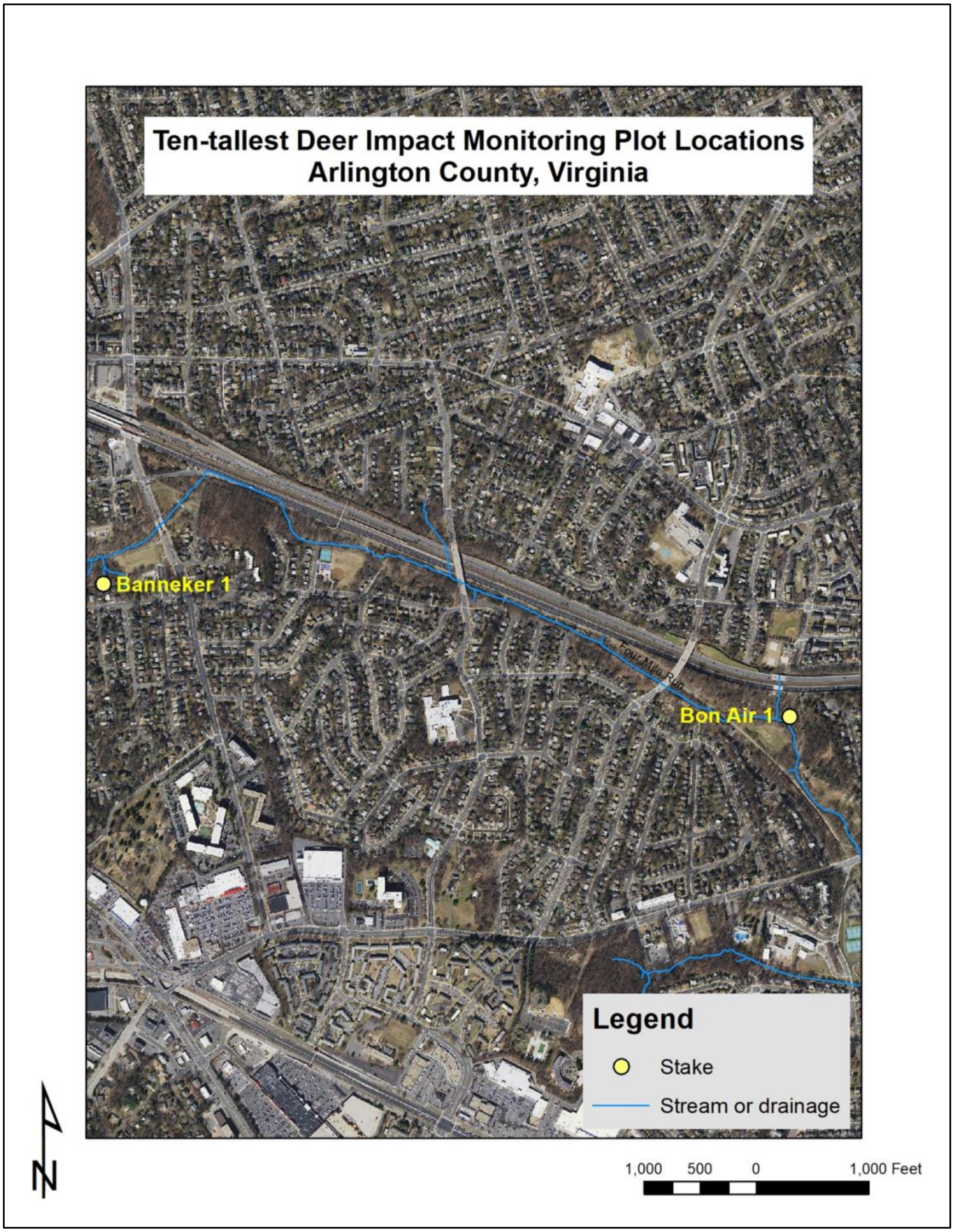


Fig. 4. Plot locations for Bon Air and Benjamin Banneker Parks.

Fig. 5. Plot locations for Bluemont and Bluemont Junction Parks.

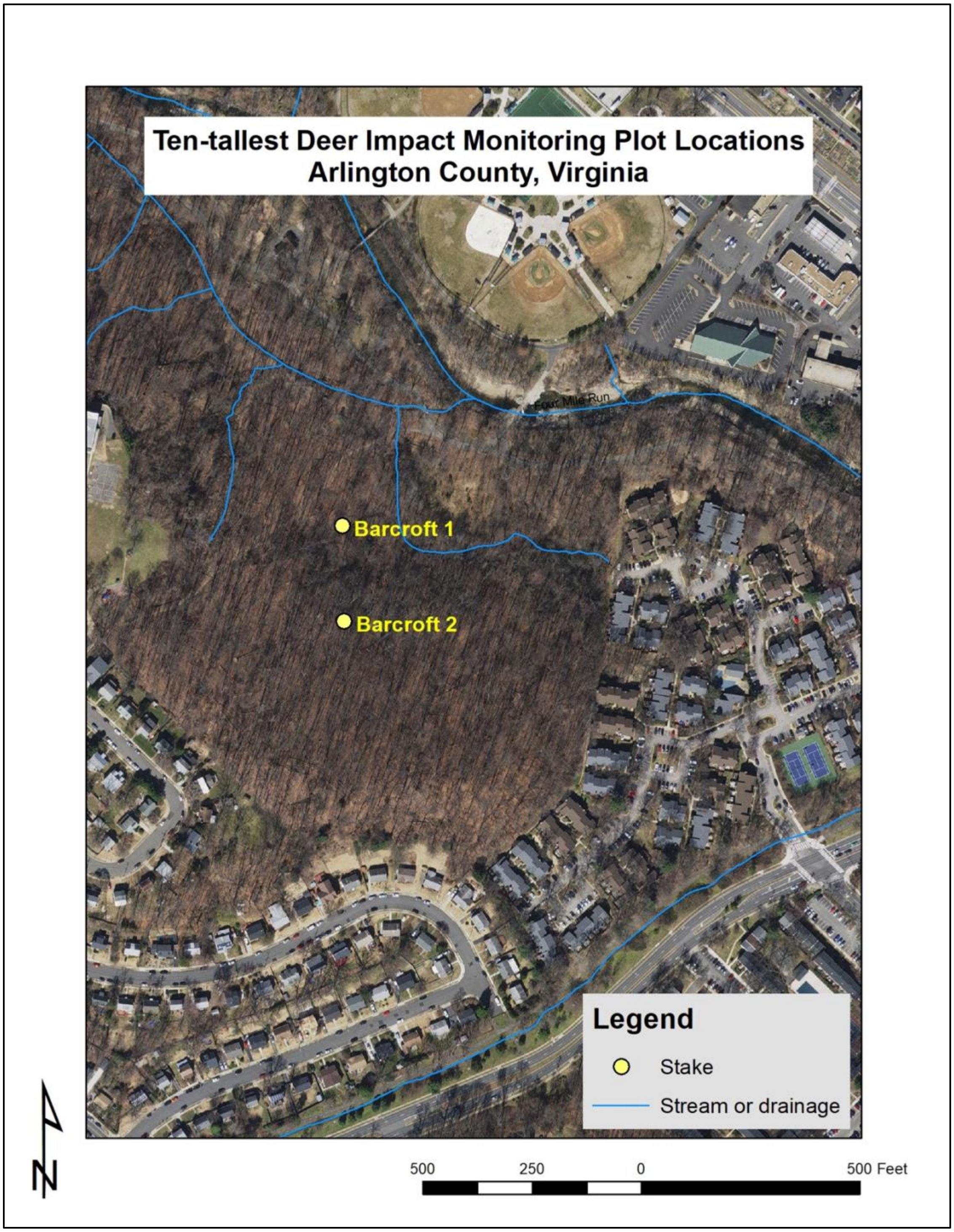


Fig. 6. Plot locations for Barcroft Park.

Fig. *7*. Plot center at Fort C.F. Smith Park (38.9022^0 lat., -77.0888^0 long.), where eastern red-cedar was sampled.

Fig. 8. Barcroft 1 (38.8470^0 lat., -77.1029^0 long.), where spicebush was sampled.

Fig. 9. Barcroft 2 (38.8464^0 lat., -77.1029^0 long.), where chestnut oak was sampled.

Fig. 10. Banneker 1 (38.8820^0 lat., -77.1572^0 long.), where catalpa was sampled.

Fig. 11. Bluemont 1 (38.8680^0 lat., -77.1316^0 long.), where ironwood was sampled.

Fig. 12. Bluemont 2 (38.8676^0 lat., -77.1311^0 long.), where spicebush was sampled.

Fig. 13. Bluemont Junction 1 (38.8710^0 lat., -77.1313^0 long.), where white oak was sampled.

Fig. 14. Bon Air 1 (38.8785^0 lat., -77.1358^0 long.), where white ash was sampled.

Fig. 15. Donaldson 1 (38.91005^0 lat., -77.11314^0 long.), where tulip tree and boxelder were sampled.

Fig. 16. Donaldson 2 (38.9143^0 lat., -77.1094^0 long.), where spicebush was sampled.

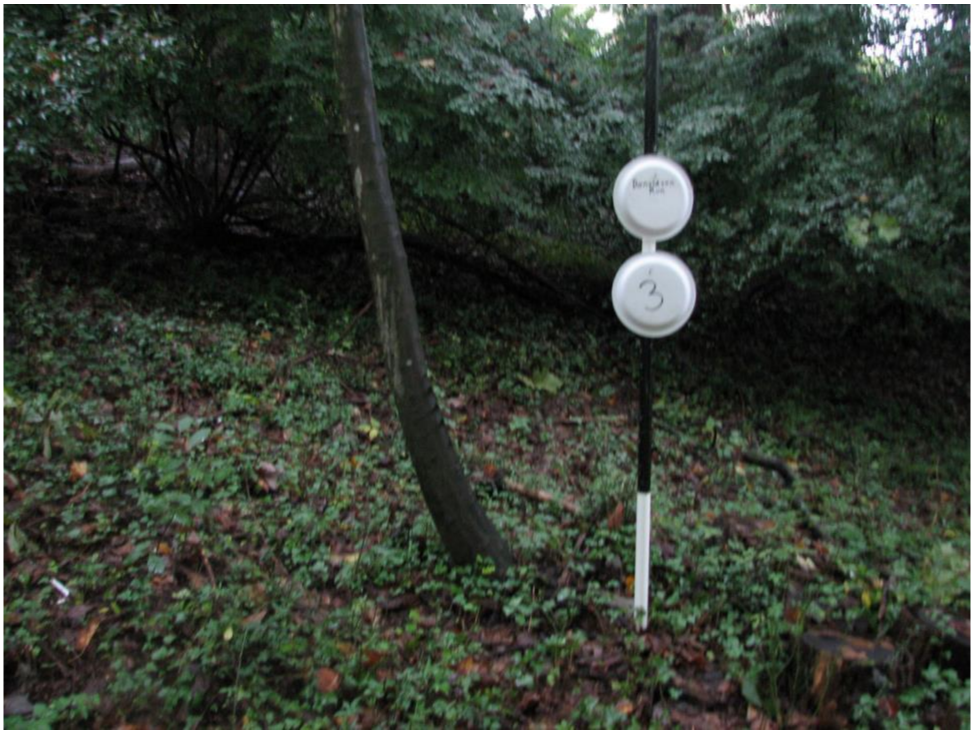


Fig. 17. Donaldson 3 (38.9090^0 lat., -77.1158^0 long.), where winged euonymus was sampled.

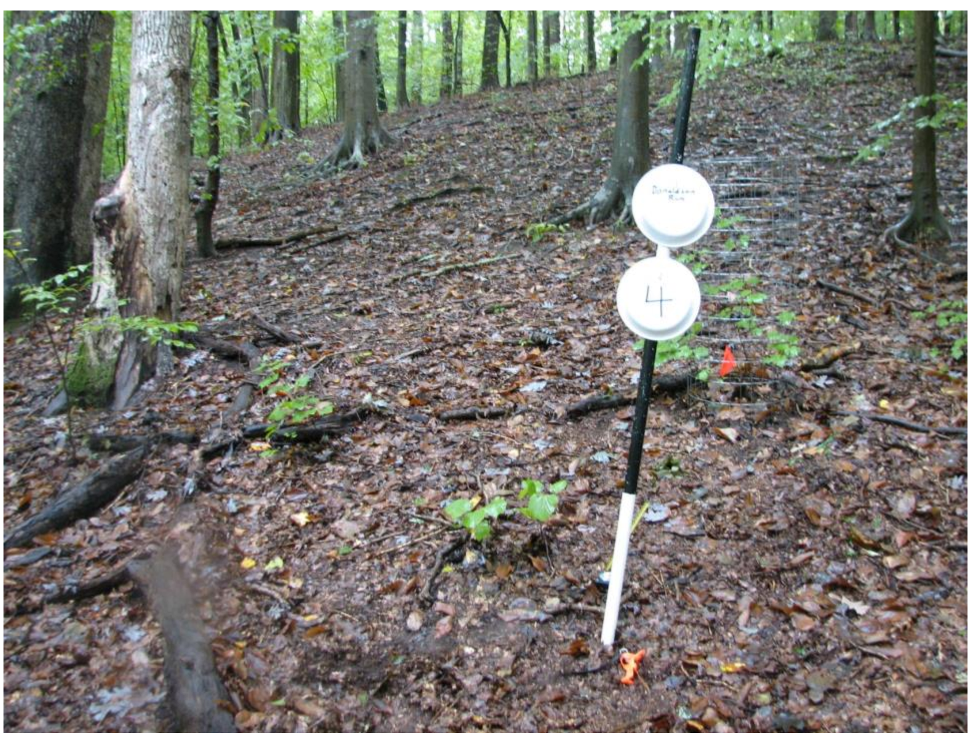


Fig. 18. Donaldson 4 (38.9140^0 lat., -77.1105^0 long.), where strawberry bush and maple-leaf viburnum were sampled.

Fig. 19. Donaldson 5 (38.9153^0 lat., -77.1103^0 long.), where maple-leaf viburnum and chestnut oak were sampled.

Fig. 20. Glencarlyn 1 (38.85998^0 lat., -77.1238^0 long.), where maple-leaf viburnum was sampled.

Fig. 21. Glencarlyn 2 (38.8606^0 lat., -77.1243^0 long.), where white oak was sampled.

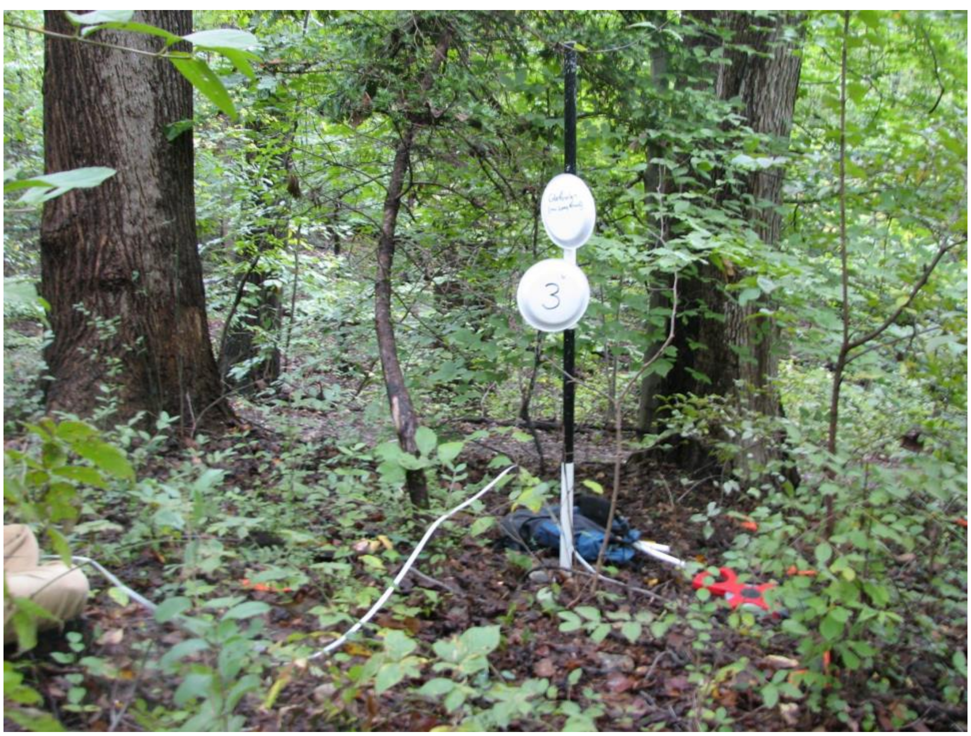


Fig. 22. Glencarlyn 3 (38.8606^0 lat., -77.1230^0 long.), where strawberry bush was sampled.

Fig. 23. Glencarlyn 4 (38.8630^0 lat., -77.1201^0 long.), where maple-leaf viburnum and chestnut oak were sampled.

Fig. 24. Glencarlyn 5 (38.8621^0 lat., -77.1193^0 long.), where chestnut oak and black cherry were sampled.

Fig. 25. Glencarlyn 6 (38.8638^0 lat., -77.1203^0 long.), where maple-leaf viburnum was sampled.

Fig. 26. Glencarlyn 7 (38.8669^0 lat., -77.1262^0 long.), where maple-leaf viburnum was sampled.

Fig. 27. Gulf Branch 1 (38.9237^0 lat., -77.1145^0 long.), where white ash and maple-leaf viburnum were sampled.

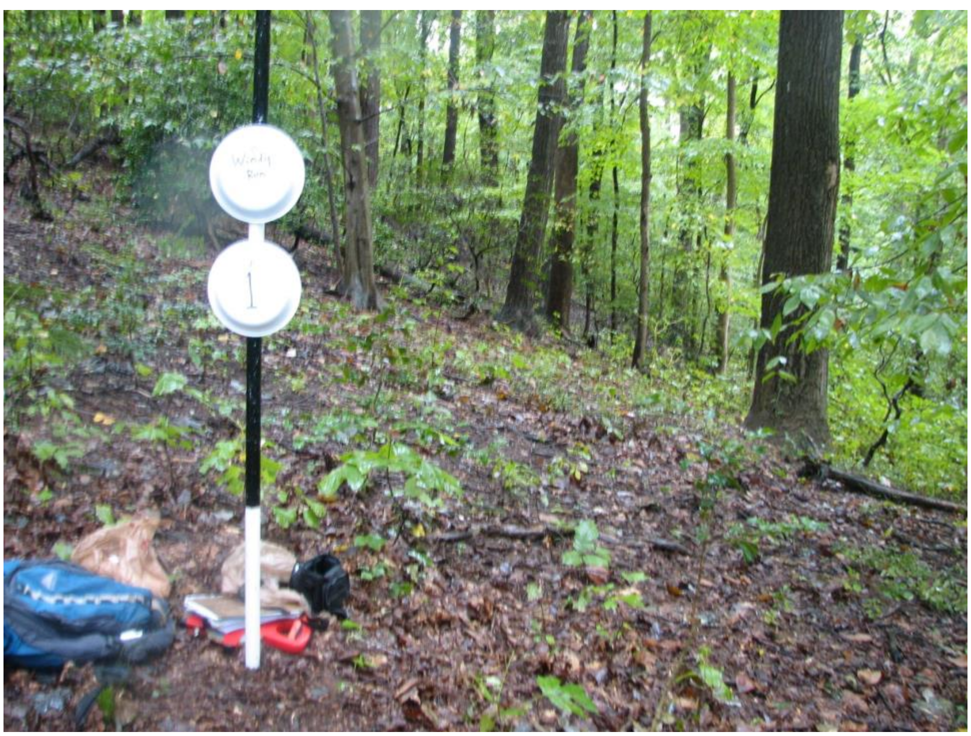


Fig. 28. Windy Run 1 (38.9046^0 lat., -77.0956^0 long.), where black cherry, tulip tree, maple-leaf viburnum, and chestnut oak were sampled.

Fig. 29. Spicebush at Barcroft 1.

Fig. 30. Unbrowsed white snakeroot at Barcroft 1.

Fig. 31. Unbrowsed sweetbay magnolia near Barcroft 1.

Fig. 32. Chestnut oak at Barcroft 2.

Fig. 33. Browsed catalpas at Banneker 1. Note the Japanese stiltgrass in the photograph, a grass that is widespread in Arlington and is rarely if ever browsed by deer.

Fig. 34. Small ironwood sapling at Bluemont 1.

Fig. 35. Browsed white ash at Bon Air 1.

Fig. 36. Tulip tree at Donaldson 1 showing browsed leaf blades.

Fig. 37. Spicebush at Donaldson 2.

Fig. 38. Browsed winged euonymus at Donaldson 3.

Fig. 39. Browsed strawberry bush at Donaldson 4.

Fig. 40. Caged viburnum at Donaldson 4.

Fig. 41. Viburnum stem at Glencarlyn 1 suppressed by deer browsing.

Fig. 42. White oak at Glencarlyn 2.

Fig. 43. Browsed strawberry bush at Glencarlyn 3.

Fig. 44. Chestnut oak at Glencarlyn 4.

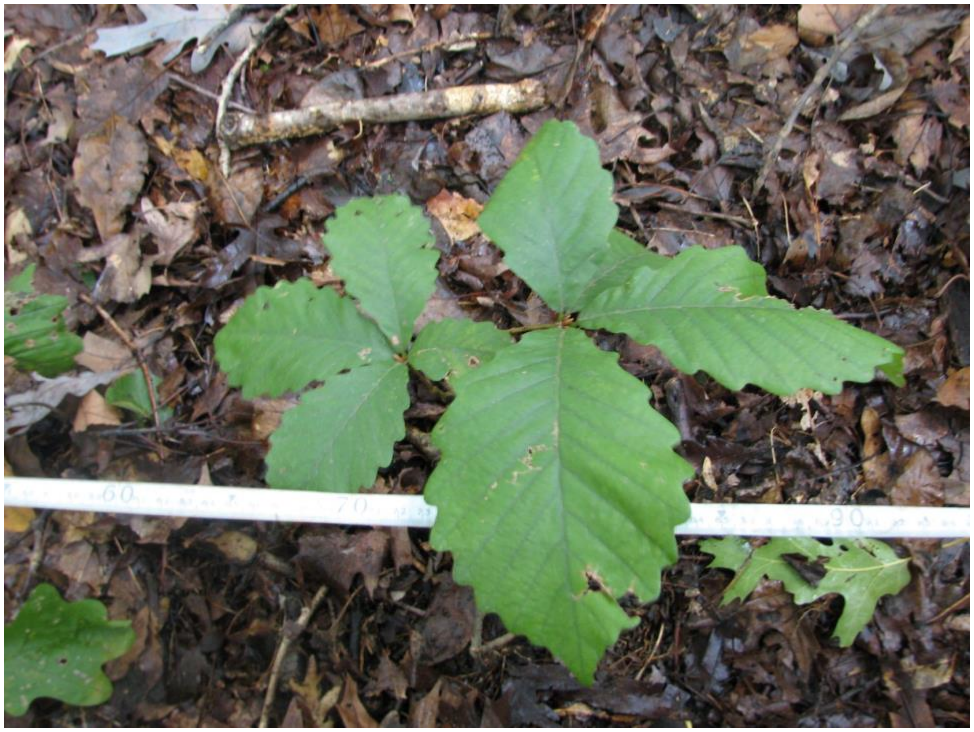


Fig. 45. Chestnut oak at Glencarlyn 5.

Fig. 46. Black cherry at Glencarlyn 5.

Fig. 47. Fruiting viburnum at Glencarlyn 6.

Fig. 48. Unbrowsed flowering dogwood at Glencarlyn 6.

Fig. 49. Unbrowsed bluestem goldenrod (*Solidago caesia*) at Glencarlyn 6.

Fig. 50. Browsed wild hydrangea at Gulf Branch 1.

Fig. 51. Deformed stem of white ash at Gulf Branch 1.

Fig. 52. Basal sprouts of mountain laurel near Windy Run 1, kept short by deer browsing.

Fig. 53. Tagged eastern red-cedars at C.F. Smith 1.

Appendix A1: Example of a completed ten-tallest plot form

Ten-tallest Method for Deer Impact Monitoring

This form is used to document and monitor understory plant populations for height growth, reproductive condition, abundance and browse damage.
Data are typically gathered from a circular 100 square meter plot (5.64 m or 18.5 ft. radius) marked by a central numbered stake.

Site Name Barcroft Park

Site Location *State:* VA *County:* Arlington *City, Town or Village:* N/A

Plot Location Arlington County Department of Parks & Recreation property

Barcroft Park. On shoulder of steep slope near the upper terminus of a gully. Near a relatively large chestnut oak tree.

Latitude: 38.8464 *Longitude:* -77.1029

Plot Number **Barcroft 2 Quercus prinus**

(Note: Plot number consists of site name, stake number and species, e.g., Rheinstrom 1 White Oak.)

Plot Center Marked with: ¾ inch diameter PVC pipe section

Species Monitored **Chestnut Oak *(Quercus prinus)***

Number of Individuals in Plot: 10-20 21-50 51-100 >100 *Actual Count:*

Observer(s)	*Observer(s)*	*Observer(s)*	*Observer(s)*	*Observer(s)*
Thomas J. Rawinski				
Date: 6-Oct-22	*Date:*	*Date:*	*Date:*	*Date:*
No. of Reproductive Individuals in Plot	No. of Reproductive Individuals in Plot	No. of Reproductive Individuals in Plot	No. of Reproductive Individuals in Plot	No. of Reproductive Individuals in Plot

Height of the Ten Tallest Stems, and Evidence of Browse Damage

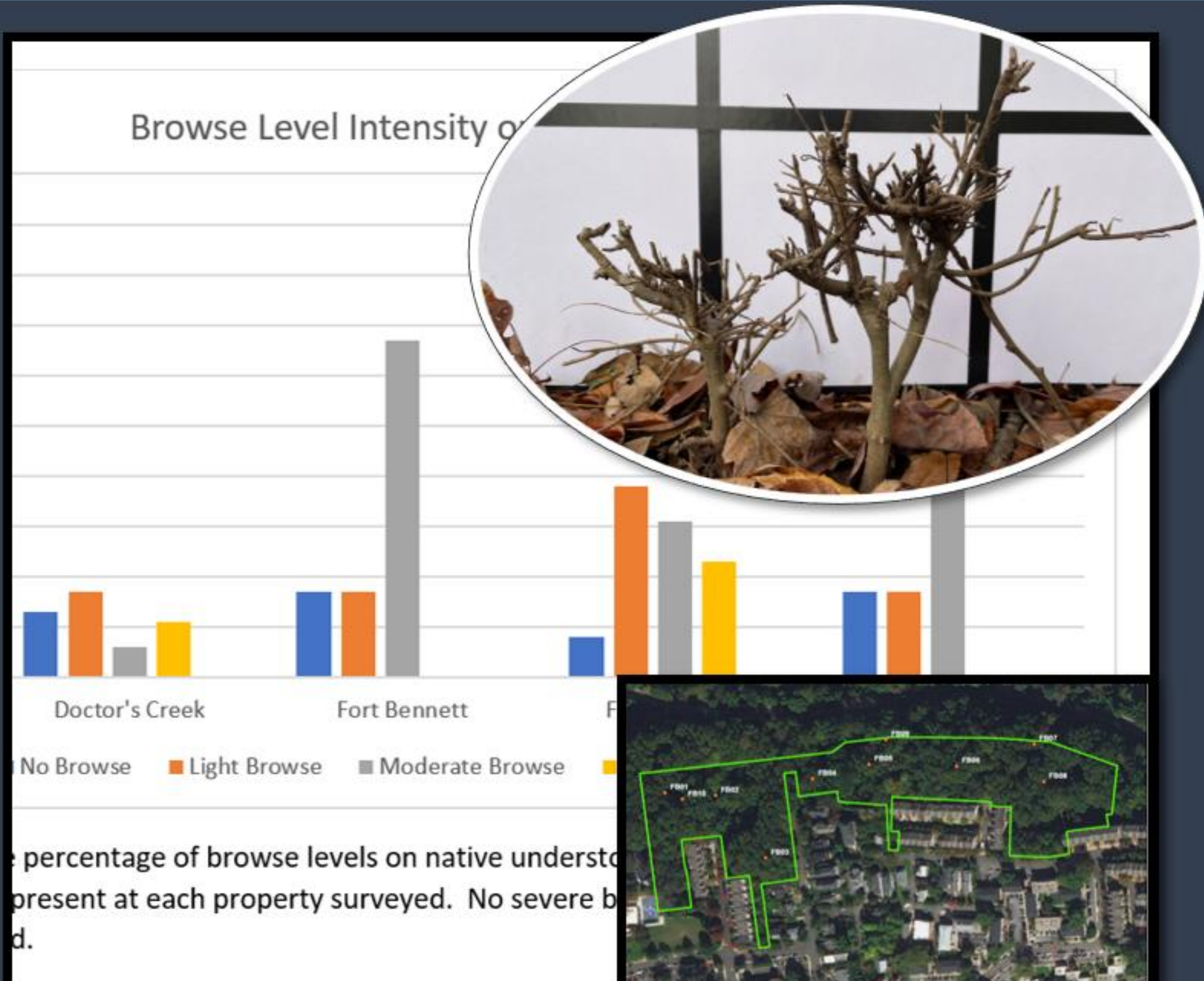
Plant No.	*Ht. (in)*	*Browsed? (Y/N/?)*	*Plant No.*	*Ht. (in)*	*Browsed? (Y/N/?)*	*Plant No.*	*Ht. (in)*	*Browsed? (Y/N/?)*	*Plant No.*	*Ht. (in)*	*Browsed? (Y/N/?)*	*Plant No.*	*Ht. (in)*	*Browsed? (Y/N/?)*
1	23	Y	1			1			1			1		
2	22.5	Y	2			2			2			2		
3	23	Y	3			3			3			3		
4	21	Y	4			4			4			4		
5	22	Y	5			5			5			5		
6	36.5	Y	6			6			6			6		
7	25	Y	7			7			7			7		
8	25.5	Y	8			8			8			8		
9	34	Y	9			9			9			9		
10	21.5	Y	10			10			10			10		
Avg. Ht.	25.4		*Avg. Ht.*	#DIV/0!		*Avg. Ht.*	#DIV/0!		*Avg. Ht.*	#DIV/0!		*Avg. Ht.*	#DIV/0!	

Notes For some stems, browse damage was inferred by crooked stem growth.
Most of the Quercus prinus stems are about 12 in. tall. Deer beds observed nearby. As many as 14 deer seen here in the past.

DATA BRIEF

Appendix B – Forest Health Assessments in Relation to White-tailed Deer Browsing

Arlington County, Virginia - Fall 2022



Data Brief

Results of the vegetation assessment performed in selected Arlington County Parks are provided in this document. White Buffalo Inc. (WBI) subcontracted Steward Green LLC (SG) to provide these monitoring services for Arlington County Parks and Recreation. The data presented here provide a baseline assessment of forest health and deer browse impact. This brief summarizes the project and methodology and presents the results of deer browse impact and vegetation monitoring. All collected data are displayed in table and graph formats.

Executive Summary

Four properties within the Arlington County Park System (Doctor's Run Park, Fort Bennett Park, Fort C.F. Smith Park, and Grandma's Creek parcel of Glencarlyn Park) were assessed for deer browse impacts on the understory vegetation within forested areas. Monitoring was performed by quantifying deer browse intensity on native understory species (Fig. 1) and current composition and density of forest understory. These data were collected at ten randomly selected study plots at each property in early November of 2022. All properties included in this survey displayed signs of overabundant deer browsing, including low levels of native regeneration, native understory plants dominated by species less desirable to deer, and high browse rates. Native understory vegetation was browsed by deer at a mean rate of 86% throughout the study area. This rate suggests that current deer browse pressure prohibits forest regeneration. In addition, deer browsing on non-native vegetation was present within the plots at all four properties.

In the properties surveyed, 83% to 92% of native plants in the survey area displayed some degree of deer browsing (Fig. 2). The deer browse rates recorded in this survey are considered severe, and it should be assumed that the negative ecological impacts of overabundant deer populations have been occurring on these properties. This assumption is supported by the observations and data collected during the time of monitoring. Heavy deer browsing is known to alter native species composition, negatively impacting biodiversity and promoting the presence of non-native species (Kelly 2019). Heavy deer browse rates also limit forest regeneration by preventing plant reproduction. A recent study found that a browse rate exceeding 10–15% on red oak (*Quercus rubra)* seedlings created trees that were unlikely to flower and seed, making them unable to create future generations of their species (Blossey et al. 2019). A desired deer browse rate for native understory vegetation suggested by regional ecologists is less than 10% (M. VanClef, Ecological Solutions, personal communication).

For this survey, our methods included categorizing the deer browse impact level for each plant in the study area, these levels ranged from no impact to severe impact (Fig. 3). Amongst the vegetation sampled, moderate level deer browse impact was the most common level documented, with 60%, 67%, 31% and 67% of plants at the properties displaying moderate impact. For this study, moderate level deer browse impact is defined as greater than 50% of twigs displaying deer browsing, without any signs of hedging. Severe browse impact was observed in half of the properties yet was not captured in the randomized survey areas. The levels of browse impact observed and recorded throughout the parks surveyed commonly create conditions that prevent the forest from regenerating.

Current composition of the forest understory was performed using the Forest Secchi method. Existing native cover in the understory varied from 21% native cover at Grandma's Creek to 65% native cover at Fort Bennett Park. Overall, total understory vegetation cover at Grandma's Creek was 24%; however, 80% of the study plots contained no native regeneration. At Fort Bennett, total vegetation cover in the understory was 66%. Two of the ten plots lacked native regeneration; however, the most documented native understory species were spicebush (*Lindera benzoin*) and greenbrier (*Smilax* spp.), both of which are known to be less desirable browse for deer. Within the mid-Atlantic states, some forest ecologists use 70% native vegetation cover in the understory as a benchmark for a recovered forest (M. VanClef, Ecological Solutions, personal communication). Cover of non-native species in the understory ranged from 2% to 12% in the study areas. Intense infestations were observed in the parks surveyed. Study points GC06 and GC09 captured portions of these infestations. It is important to note that Arlington County is performing active invasive species management in their parkland. Evidence of recent herbicide treatments was observed at Grandma's Creek. Forest ecologists suggest a maximum of 5% cover of non-native understory in forests to support ecological function and regeneration (M. VanClef, Ecological Solutions, personal communication). Heavy deer browse rates, browse impacts recorded for individual plants, and presence of invasive species together threaten the health, longevity, and resilience of these habitats.

Graphical Data Summary

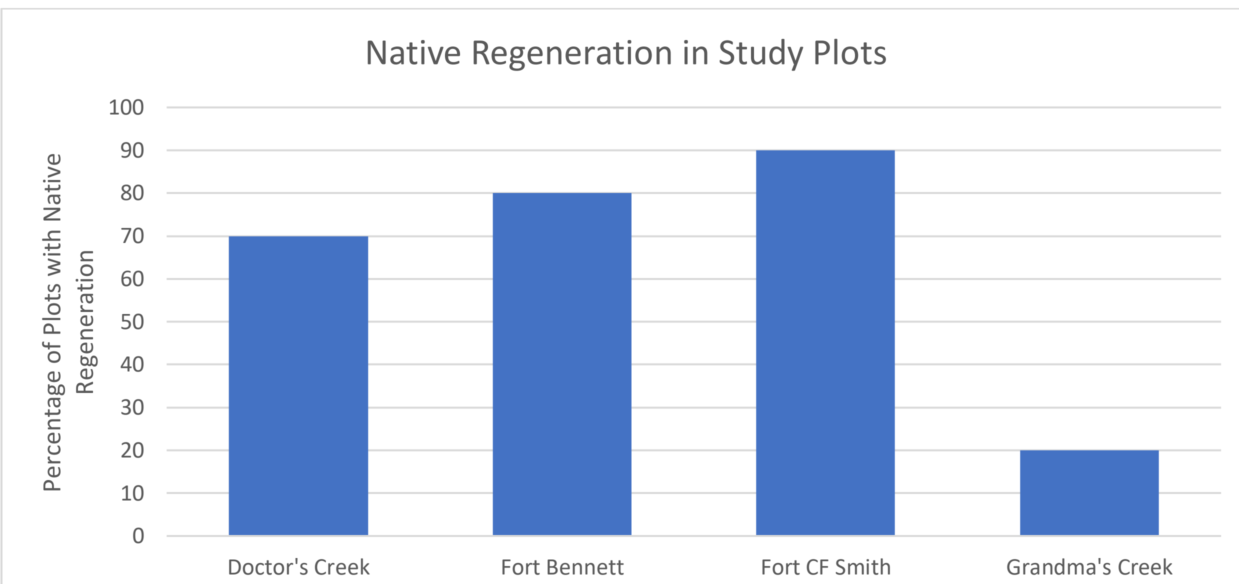


Figure 1. Deer browse impact data were collected in study plots that contained native shrubs and trees that were at least six inches in height. This graph illustrates the percentage of plants that included native understory. At Grandma's Creek, only 20% of the plots contained native understory.

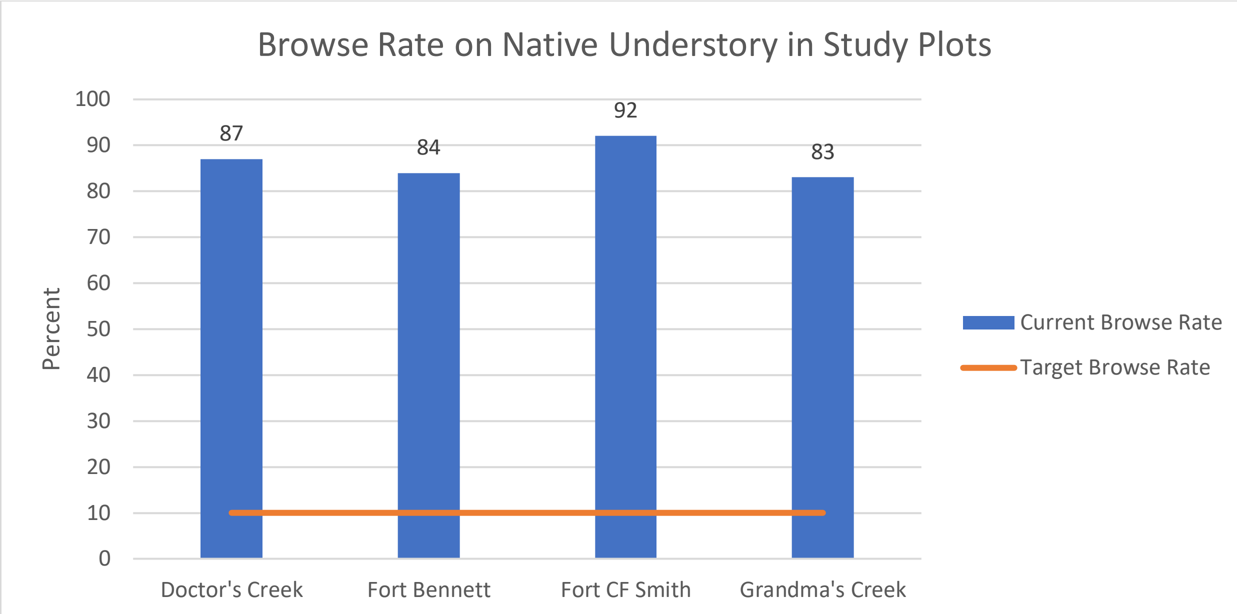


Figure 2. Mean deer browse rates on native understory in the study plots. This chart shows the percentage of native understory stems that had some degree of browsing. For example, native understory at Fort CF Smith was browsed by deer at a rate of 92%. A subjective desired browse rate of 10% is depicted by the threshold line.

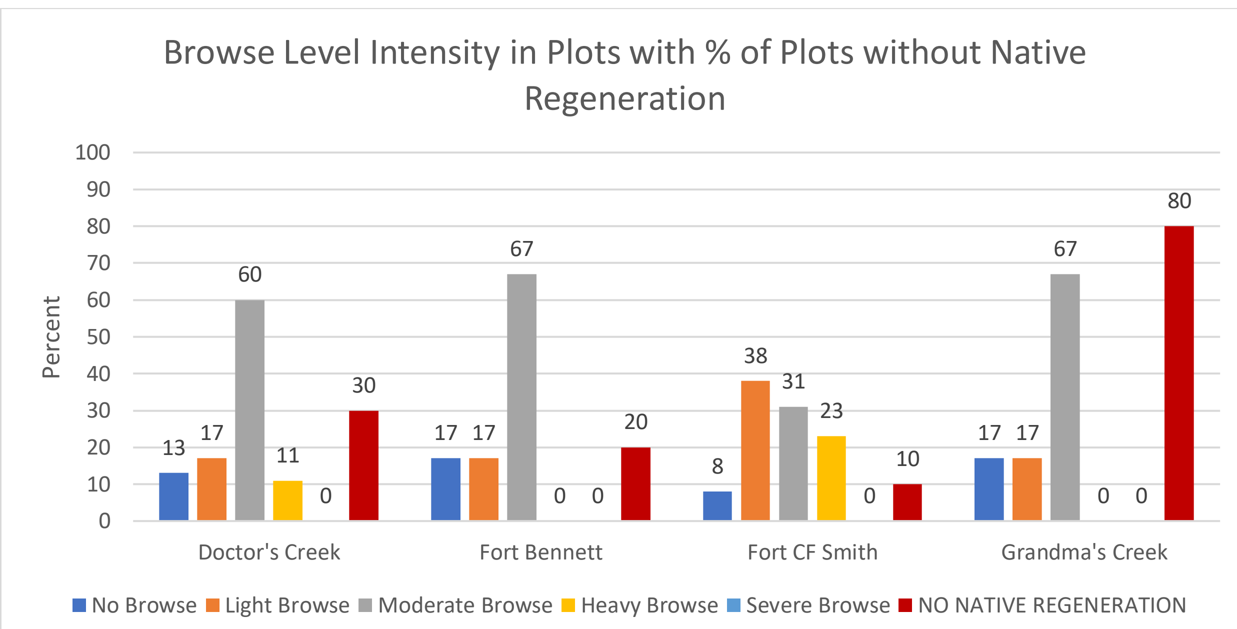


Figure 3. The percentage of browse levels on native understory vegetation that were present at each property and the percentage of study plots that did not contain native regeneration. Deer browsing was present at each property surveyed. Moderate browse impact (i.e., >50% of the twigs browsed, plant is not hedged) was the most common level documented in the study plots. No severe browse was recorded in the plots; however, it was observed at Fort CF Smith and Grandma's Creek.

Study Overview and Methodology

Project Scope

Steward Green LLC (SG) provided vegetation monitoring services to White Buffalo Inc., for Arlington County Parks and Recreation as part of a larger deer management services contract. SG monitored four parcels owned by Arlington County (Figs. 4–7). These properties are as follows:

- Doctor's Run Park (6 acres), 1301 South George Mason Drive
- Fort Bennett Park (11 acres), 2220 North Scott Street
- Fort C.F. Smith Park (19 acres), 2411 24th Street North
- Grandma's Creek Parcel of Glencarlyn Park (5.5 acres), 301 South Harrison Street

Vegetation monitoring included rapid assessment methodology that captures deer browse impact and understory composition. Steward Green's deer impact methodology is based on the deCalesta method (Pierson and deCalesta 2015), also used by Fairfax County, VA, for quantifying deer browse intensity, but did not limit sampling to six species. Understory composition was measured utilizing the forest secchi board methodology (VanClef 2022).
For the Arlington County study, each property received a total of 10 study plots, with 40 study plots in total. The plot per acreage rates ranged from one plot per half acre to one plot per two acres. Plots were selected randomly utilizing QGIS software. Due to size constraints, plots were approximately 50 meters from each other, where plots are typically placed in 100 x 100 m layouts. In general, plots were placed outside of rock outcrops, large canopy gaps, and 25 m from the forest edge.

Study Plot Maps

Figure 4. Study plot locations for Doctor’s Run Park.

Figure 5. Study plot locations for Fort Bennett Park.

Figure 6. Study plot locations for Fort C.F. Smith Park.

Figure 7. Study plot locations for Grandma’s Creek parcel within Glencarlyn Park.

Park acreage and layout required that some of the randomly generated points be abandoned in the field. Abandoned points were either on a trail, property boundary, or woodland edge, where the forest secchi readings could not be measured. Additionally, some properties had extremely steep topography that prevented field staff from collecting line-of-sight measurements at the predetermined points; these locations were also modified in the field. Therefore, a portion of the actual study plots were adjusted while in the field, to achieve 10 plots per park and accommodate small acreage, trail systems, and spatial ecology of the property.

Our monitoring protocol included two rapid assessment methodologies: one to capture deer browse impact and the other, understory composition. Both assessments were conducted at each random point. Our deer impact methodology was based on Pierson and deCalesta (2015) for quantifying deer browse intensity but was modified to be suitable for data collection after leaf-off. A permanent marker was placed at the center point of each study plot to allow for follow up monitoring to be performed at the exact location in the future. For estimating deer browse impact, deer browse intensity levels were characterized, similar to Pierson and deCalesta's (2015) methodology; however, due to the time of year, data were collected and browse impact was measured and observed on twigs only (leaf browse was not visible in most of the specimens seen due to leaf drop*)*.

Three sets of data were collected within the browse impact study plot:

- Deer browse intensity on native vegetation
- Presence/absence of deer browse intensities on invasive vegetation
- Dominant species in the study plot

In addition to these data, forest understory composition data were also collected using a forest secchi board. Percent cover of native vegetation, invasive vegetation and total vegetation were recorded.

Deer Browse Impact Methodology

Study plots for deer browse impact assessment were eight-foot diameter circles, centered on the random point. All vegetation included in the study was between six inches and six feet in height. Study plots had horizontal and vertical parameters. Any woody vegetation less than six inches in height was not included in the survey.

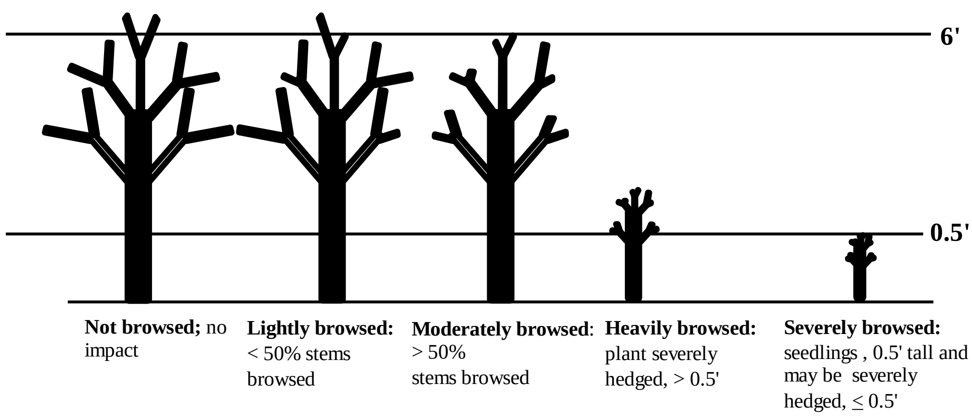
Within the parks surveyed, both rabbit and deer browsing were present. During data collection, only browsing activity by deer was counted. Rabbit and deer browsing present differently on twigs due to the differences in their dentition. Deer only have incisors on their bottom mandible, where rabbits have incisors on both top and bottom mandible. Twigs that are rabbit browsed are typically cut cleanly at a 45-degree angle. Twigs browsed by deer appear more torn than cut, have a rough edge and sometimes retain a thin section of cambium and bark.

Deer Browse Impact on Native Vegetation

In each plot, the deer browse intensity level was determined for each qualifying native plant (Fig. 8). The total number of levels represented in the plot was tallied. Browse intensity levels included:

- No Browse: no browsing observed on plant
- Light Browse: less than 50% of twigs and stem display browse
- Moderate Browse: more than 50% of the twigs display deer browse, plant is not hedged
- Heavy Browse: more than 50% of the twigs display deer browse, plant is hedged
- Severe Browse: more than 50% of the twigs display deer browse, plant is severely hedged, is just over 0.5' in height (Fig. 9)

In plots that did not contain native understory within the study area, no regeneration was recorded.



Seedlings > 0.5' provide best evidence of browsing impact. Under severe deer browsing, seedlings may never exceed 0.5' tall and will be severely hedged*: deer browsing keeps them suppressed below 0.5'. Small, current year seedlings may never grow above 0.5' under severe deer browsing.

*** Severely hedged = seedling browsed repeatedly over years; all stems short, thick, with "bonsai" appearance.**

Figure 8. Characteristic appearance of the deer browse impact levels. Figure from D. deCalesta and T. G. Pierson, unpublished report.

Figure 9. An example of severe deer browsing on native understory. Notice the hedged appearance in addition to the abundant deer browsed twigs. Image taken at Fort C.F. Smith Park. In the background the secchi board provides scale: each cell is an 8.75" square.

Deer Browsing on Invasive Understory

Within the study plots, deer browse intensity was documented on invasive trees and shrubs 0.5' to 6.0' in height. The same browse intensity levels were used when recording impact on invasive understory; however, browse levels were recorded only as presence or absence in the study plot. In instances of deer overpopulation, non-native woody vegetation will be browsed by deer, typically non-native species are less utilized than low preference native browse species. When taken as a baseline metric, occurrence of new deer browse on non-native woody understory plants can indicate a change in deer population, possibly even before seeing change in browse rates of native understory.

Dominant Understory Species

The dominant understory tree and shrub species within the study plot were recorded. Dominant species included both native and invasive species. A maximum of four species were listed per study plot.

Understory Composition – Forest Secchi Board

Forest secchi measures existing understory vegetative cover in woodland settings and this methodology was developed to provide a rapid assessment of current forest conditions (VanClef 2022). Analysis of these data can be used to determine the success of a deer management program if baseline data are recorded prior to initiation of a deer management program. This methodology measures a forest's natural response to reduced deer densities. Regional ecologists suggest a 70% native vegetation cover in the understory as a benchmark for a healthy forest (M. VanClef, Ecological Solutions, personal communication). Forest secchi measurements are taken at the same locations used for deer browse impact monitoring (Fig. 10).

The secchi board is a one-meter square whiteboard divided into a grid of 16 cells. The number of cells partially or completely obstructed by vegetation are counted and recorded, with data collection for native species, invasive species, and total understory cover recorded separately. For each plot, four readings should be taken, one reading at each cardinal point. Measurements are recorded at a distance of 10 m from the center point of the plot, the board is held 0.4 m above ground level.

Figure 10. Understory composition being measured with the forest secchi method at Grandma's Creek (left image) and Doctor's Run (right image). Note the difference in the number of cells obstructed by vegetation. Greenbrier (*Smilax* spp.), a low preference browse plant for deer, is the majority of the understory in the image from Doctor's Run.

References

Blossey, B., P. Curtis, J. Boulanger, and A. Dávalos. 2019. Red oak seedlings as indicators of deer browse pressure: gauging the outcome of different white-tailed deer management approaches. Ecology and Evolution 2019:13085–13103.

Pierson, T. G., and deCalesta, D. 2015. Methodology for estimating deer browsing impact. Human-Wildlife Interactions 9:67–77.

deCalesta, D., and T. G. Pierson. 2005. Deer Density and Deer Browse Impact Survey Protocols 2005. Unpublished report.

Kelly, J. F. 2019. Regional changes to forest understories since the mid-Twentieth Century: effects of overabundant deer and other factors in northern New Jersey. Forest Ecology and Management 444:151–162.

VanClef, M. 2022. Forest Health Monitoring Protocols. Ecological Solutions. <http://www.njecologicalsolutions.com/forestMonitoring.html>. Accessed 12 October 2022.

Data Tables

<u>Doctor's Run Park Data</u>

Table 1. Deer Browse Impact Level on Native Vegetation, Doctor's Run Park

Study Plot ID	Native Veg	No Browse	Light Browse	Moderate Browse	Heavy Browse	Severe Browse	Plants in Plot
DR01	Yes	0	2	6	0	0	8
DR02	Yes	3	0	9	0	0	12
DR03	Yes	1	0	6	0	0	7
DR04	No						0
DR05	Yes	0	0	3	1	0	4
DR06	Yes	1	3	1	0	0	5
DR07	Yes	0	0	0	1	0	1
DR08	No						0
DR09	No						0
DR10	Yes	1	3	3	3		10
Totals		6	8	28	5	0	**47**

Table 2. Presence/Absence of Deer Browse Levels on Non-native Vegetation, Doctor's Run Park

Study Plot ID	Non-native Understory	No Browse	Light Browse	Moderate Browse	Heavy Browse	Severe Browse
DR01	No					
DR02	Yes	Yes	No	No	No	No
DR03	Yes	Yes	No	No	No	No
DR04	Yes	Yes	No	Yes	No	No
DR05	No					
DR06	No					
DR07	No					
DR08	No					
DR09	No					
DR10	No					
Totals	3	3	0	1	0	0

Table 3. Dominant Understory Species in Study Plots; Doctor's Run Park

Study Plot ID	Dominant Spp 1	Dominant Spp 2	Dominant Spp 3	Dominant Spp 4
DR01	*Smilax* spp.	*Magnolia* spp.		
DR02	*Smilax* spp.			
DR03	*Smilax* spp.	*Lonicera japonica*		
DR04	*Wisteria sinensis*			
DR05	*Smilax* spp.			
DR06	*Smilax* spp.	*Quercus* spp.	*Quercus* spp.	
DR07	*Prunus* spp.			
DR08				
DR09				
DR10	*Quercus* spp.	*Viburnum prunifolium*	*Smilax* spp.	

Table 4. Raw Forest Secchi Board Data: Cells Covered by Each Vegetation Type in the Understory by Cardinal Point; Doctor's Run Park

	North			East			West			South		
	Cells covered by native vegetation	Cells covered by non-native vegetation	Total cells with vegetation coverage	Cells covered by native vegetation	Cells covered by non-native vegetation	Total cells with vegetation coverage	Cells covered by native vegetation	Cells covered by non-native vegetation	Total cells with vegetation coverage	Cells covered by native vegetation	Cells covered by non-native vegetation	Total cells with vegetation coverage
DR01	13	7	14	7	2	8	5	0	5	16	0	16
DR02	16	0	16	16	6	16	16	3	16	8	12	16
DR03	11	0	11	16	0	16	12	0	12	16	0	16
DR04	16	0	16	0	0	0	13	6	16	11	0	11
DR05	16	0	16	10	1	11	2	9	10	16	0	16
DR06	12	0	12	9	0	9	10	4	16	7	0	7
DR07	4	0	4	11	0	11	13	0	13	7	0	7
DR08	0	0	0	0	0	0	0	13	13	11	0	11
DR09	11	0	11	2	0	2	NA	NA	NA	15	2	16
DR10	15	8	16	9	0	9	14	0	14	11	4	15

Table 5. Mean Percent Cover of Vegetation Types in Forest Understory, Doctor's Run Park

Study Plot	% Native Cover	% Invasive Cover	% Total Cover
DR01	0.64	0.14	0.67
DR02	0.88	0.33	1.00
DR03	0.86	0.00	0.86
DR04	0.63	0.09	0.67
DR05	0.69	0.16	0.83
DR06	0.59	0.06	0.69
DR07	0.55	0.00	0.55
DR08	0.17	0.20	0.38
DR09	0.58	0.04	0.60
DR10	0.77	0.19	0.84
Mean % Cover	0.63	0.12	0.71

Fort Bennett Park Data

Table 6. Deer Browse Impact Level on Native Vegetation, Fort Bennett Park

Study Plot ID	Native Veg	No Browse	Light Browse	Moderate Browse	Heavy Browse	Severe Browse	Total Plants in Plot
FB01	Yes	0	0	2	0	0	2
FB02	Yes	2	0	2	0	0	4
FB03	No						0
FB04	Yes	1	0	0	0	0	1
FB05	Yes	0	1	0	0	0	1
FB06	Yes	0	2	1	0	0	3
FB07	No						0
FB08	Yes	0	0	2	0	0	2
FB09	Yes	0	0	4	0	0	4
FB10	Yes	0	0	1	0	0	1
Totals		3	3	12	0	0	**18**

Table 7. Presence/Absence of Deer Browse Levels on Non-native Vegetation, Fort Bennett Park

Study Plot ID	Invasive Understory	No Browse	Light Browse	Moderate Browse	Heavy Browse	Severe Browse
FB01	**No**					
FB02	**Yes**	Yes	No	No	No	No
FB03	**No**					
FB04	**No**					
FB05	**No**					
FB06	**No**					
FB07	**No**					
FB08	**Yes**	Yes	Yes	No	No	No
FB09	**Yes**	Yes	No	No	No	No
FB10	**Yes**	Yes	Yes	No	Yes	No
Totals	4	4	2	0	1	0

Table 8. Dominant Understory Species in Study Plots, Fort Bennett Park

Study Plot ID	Dominant Species 1	Dominant Species 2	Dominant Species 3	Dominant Species 4
FB01	*Smilax* spp.			
FB02	*Euonymus americanus*	*Fraxinus* spp.	*Lonicera japonica*	*Lindera benzoin*
FB03				
FB04	*Lindera benzoin*			
FB05	*Lindera benzoin*			
FB06	*Lindera benzoin*			
FB07				
FB08	*Lindera benzoin*	*Viburnum dilatatum*	*Lonicera japonica*	
FB09	*Lindera benzoin*	*Euonymus fortunei*	*Lonicera japonica*	
FB10	*Lonicera japonica*	*Smilax* spp.	*Euonymus alatus*	

Table 9. Raw Forest Secchi Board Data: Cells Covered by Each Vegetation Type in the Understory by Cardinal Point, Fort Bennett Park

	North			East			South			West		
	Cells covered by native vegetation	Cells covered by non-native vegetation	Total cells with vegetation coverage	Cells covered by native vegetation	Cells covered by non-native vegetation	Total cells with vegetation coverage	Cells covered by native vegetation	Cells covered by non-native vegetation	Total cells with vegetation coverage	Cells covered by native vegetation	Cells covered by non-native vegetation	Total cells with vegetation coverage
FB01	16	3	16	0	0	0	0	0	0	14	0	14
FB02	11	1	12	13	0	13	8	0	8	15	0	15
FB03	10	0	10	16	0	16	9	0	9	10	0	10
FB04	15	0	15	14	0	14	16	16	16	16	0	16
FB05	5	0	5	13	0	13	16	0	16	9	0	9
FB06	13	0	13	16	0	16	NA	NA	NA	13	0	13
FB07	0	0	0	13	0	13	NA	NA	NA	9	0	9
FB08	8	0	8	13	0	13	0	5	5	9	3	11
FB09	16	16	16	11	0	11	NA	NA	NA	3	0	3
FB10	1	0	1	5	0	5	16	0	16	14	0	14

Table 10. Mean Percent Cover of Vegetation Types in Forest Understory, Fort Bennett Park

Study Plot	% Native Cover	% Invasive Cover	% Total Cover
FB01	0.47	0.05	0.47
FB02	0.73	0.02	0.75
FB03	0.70	0.00	0.70
FB04	0.95	0.25	0.95
FB05	0.67	0.00	0.67
FB06	0.88	0.00	0.88
FB07	0.46	0.00	0.46
FB08	0.47	0.13	0.58
FB09	0.63	0.33	0.63
FB10	0.56	0.00	0.56
FB Mean % Cover	0.65	0.08	0.66

Fort C.F. Smith Park Data

Table 11. Deer Browse Impact Level on Native Vegetation, Fort C.F. Smith Park

Study Plot ID	Native Veg	No Browse	Light Browse	Moderate Browse	Heavy Browse	Severe Browse	Plants in Plots
CF01	Yes	0	0	0	1	0	1
CF02	yes	0	0	1	0	0	1
CF03	yes	0	2	0	0	0	2
CF04	yes	0	1	1	0	0	2
CF05	Yes	0	0	0	1	0	1
CF06	Yes	0	1	0	0	0	1
CF07	No						0
CF08	Yes	0	0	1	0	0	1
CF09	Yes	0	1	1	0	0	2
CF10	Yes	1	0	0	1	0	2
Totals	9	1	5	4	3	0	**13**

Table 12. Presence/Absence of Deer Browse Levels on Non-native Vegetation, Fort C.F. Smith Park

Study Plot ID	Non-native Understory	No Browse	Light Browse	Moderate Browse	Heavy Browse	Severe Browse
CF01	No					
CF02	No					
CF03	No					
CF04	No					
CF05	No					
CF06	No					
CF07	No					
CF08	Yes	Yes	No	No	No	No
CF09	No					
CF10	No					
Presence of Browse Level Totals		1	0	0	0	0

Table 13. Dominant Understory Species in Study Plots, Fort C.F. Smith Park

Study Plot ID	Dominant Species 1	Dominant Species 2	Dominant Species 3	Dominant Species 4
CF01	Crataegus spp.			
CF02	*Fraxinus* spp.			
CF03	*Lindera benzoin*			
CF04	*Lindera benzoin*			
CF05	*Asimina triloba*			
CF06	*Lindera benzoin*			
CF07				
CF08	*Lindera benzoin*	*Celastrus orbiculatus*		
CF09	*Lindera benzoin*			
CF10	*Ulmus* spp.	*Juniperus virginiana*		

Table 14. Raw Forest Secchi Board Data; Cells Covered by Each Vegetation Type in the Understory by Cardinal Point, Fort C.F. Smith Park

	North			East			South			West		
	Cells covered by native vegetation	Cells covered by non-native vegetation	Total cells with vegetation coverage	Cells covered by native vegetation	Cells covered by non-native vegetation	Total cells with vegetation coverage	Cells covered by native vegetation	Cells covered by non-native vegetation	Total cells with vegetation coverage	Cells covered by native vegetation	Cells covered by non-native vegetation	Total cells with vegetation coverage
CF01	8	0	8	0	0	0	9	0	9	11	14	15
CF02	10	0	10	10	0	10	7	0	7	16	0	16
CF03	11	0	11	14	0	14	16	0	16	16	0	16
CF04	14	0	14	16	0	16	15	0	15	7	0	7
CF05	15	0	15	14	0	14	14	0	14	0	0	0
CF06	11	0	11	5	1	5	13	0	13	12	0	12
CF07	0	0	0	4	0	4	11	0	11	0	0	0
CF08	9	0	9	11	0	11	14	0	14	7	0	7
CF09	14	0	14	12	0	12	9	0	9	4	0	4
CF10	0	0	0	0	0	0	1	0	1	8	0	8

Table 15. Mean Percent Cover of Vegetation Types in Forest Understory, Fort C.F. Smith Park

Study Plot	Plot % Native	Plot % Invasive	Plot % total cover
CF01	0.44	0.22	0.50
CF02	0.67	0.00	0.67
CF03	0.89	0.00	0.89
CF04	0.81	0.00	0.81
CF05	0.67	0.00	0.67
CF06	0.64	0.02	0.64
CF07	0.23	0.00	0.23
CF08	0.64	0.00	0.64
CF09	0.61	0.00	0.61
CF10	0.14	0.00	0.14
Totals	0.58	0.02	0.58

Grandma's Creek Parcel Data

Table 16. Deer Browse Impact Level on Native Vegetation, Grandma's Creek Parcel

Study Plot ID	Native Understory	No Browse	Light Browse	Moderate Browse	Heavy Browse	Severe Browse	Plants in Plot
GC01	No						
GC02	No						
GC03	No						
GC04	No						
GC05	No						
GC06	No						
GC07	No						
GC08	Yes	0	1	1	0	0	2
GC09	Yes	1	0	3	0	0	4
GC10	No						
Totals	2 plots	1	1	4	0	0	6

Table 17. Presence/Absence of Deer Browse Levels on Non-native Vegetation, Grandma's Creek Parcel

Study Plot ID	Non-native Understory	No Browse	Light Browse	Moderate Browse	Heavy Browse	Severe Browse
GC01	No					
GC02	No					
GC03	No					
GC04	No					
GC05	No					
GC06	No					
GC07	No					
GC08	Yes	No	No	No	Yes	No
GC09	Yes	Yes	No	No	No	No
GC10	No					
Presence of Browse Level		1	0	0	1	0

Table 18. Dominant Understory Species in Study Plots, Grandma's Creek Parcel

Study Plot ID	Dominant Species 1	Dominant Species 2	Dominant Species 3	Dominant Species 4
GC01				
GC02				
GC03				
GC04				
GC05				
GC06				
GC07				
GC08	*Prunus* spp.	*Quercus* spp.	*Viburnum dilatatum*	
GC09	*Prunus* spp.	*Fraxinus* spp.	*Hedera helix*	*Lonicera japonica*
GC10				

Table 19. Raw Forest Secchi Board Data; Cells Covered by Each Vegetation Type in the Understory by Cardinal Point, Grandma's Creek Parcel

	North			East			South			West		
	Cells covered by native vegetation	Cells covered by non-native vegetation	Total cells with vegetation coverage	Cells covered by native vegetation	Cells covered by non-native vegetation	Total cells with vegetation coverage	Cells covered by native vegetation	Cells covered by non-native vegetation	Total cells with vegetation coverage	Cells covered by native vegetation	Cells covered by non-native vegetation	Total cells with vegetation coverage
GC01	9	0	9	4	0	4	0	0	0		0	0
GC02	0	0	0	0	0	0	12	0	12	5	0	5
GC03	0	0	0	0	0	0	0	1	1	0	0	0
GC04	0	0	0	0	0	0	5	0	5	13	0	13
GC05	3	0	3	0	2	2	0	0	0	0	0	0
GC06	0	0	0	0	5	5	8	0	8	0	0	0
GC07	1	0	1	4	0	4	12	0	12	7	0	7
GC08	15	0	15	0	0	0	0	0	0	6	0	6
GC09	2	0	2	NA	NA	NA	0	0	0	0	8	8
GC10	0	0	0	NA	NA	NA	6	0	6	15	0	15

Table 20. Mean Percent Cover of Vegetation Types in Forest Understory, Grandma's Creek Parcel

Study Plot	Plot % Native	Plot % Invasive	Plot % Total Cover
GC01	0.20	0.00	0.20
GC02	0.27	0.00	0.27
GC03	0.00	0.02	0.02
GC04	0.28	0.00	0.28
GC05	0.05	0.03	0.08
GC06	0.13	0.08	0.20
GC07	0.38	0.00	0.38
GC08	0.33	0.00	0.33
GC09	0.04	0.17	0.21
GC10	0.44	0.00	0.44
Totals	0.21	0.03	0.24

Graphical Depiction of Data

Overview of Properties (Note: figure numbers restart for this section)

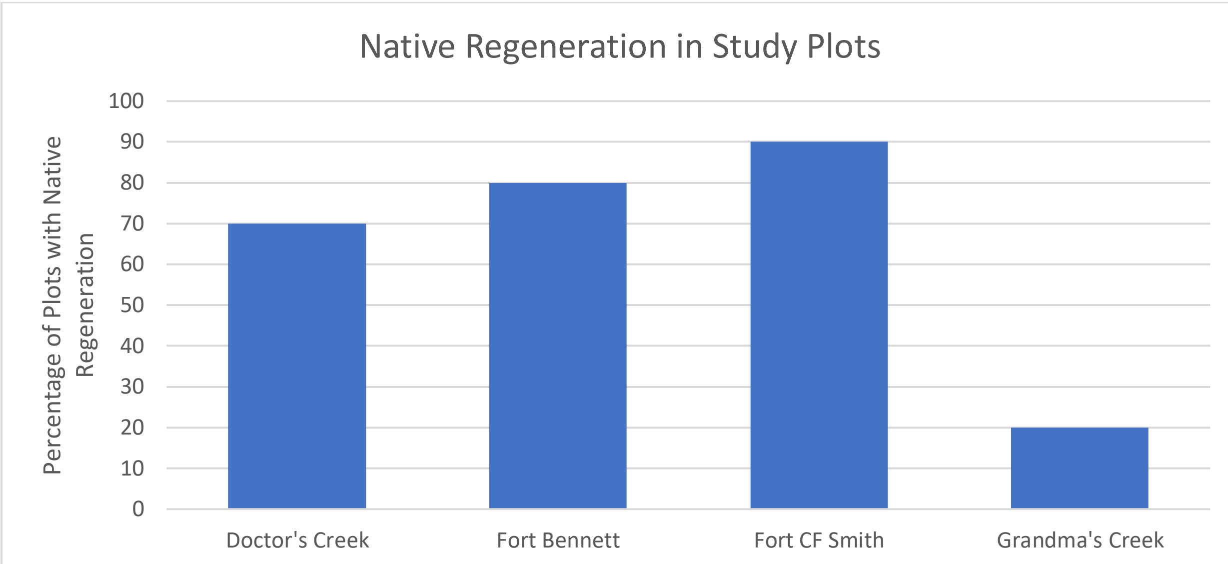


Figure 1. Browse level data were collected in study plots that contained native shrubs and trees that were at least six inches tall. This graph illustrates the percentage of plots that contained native understory at each property.

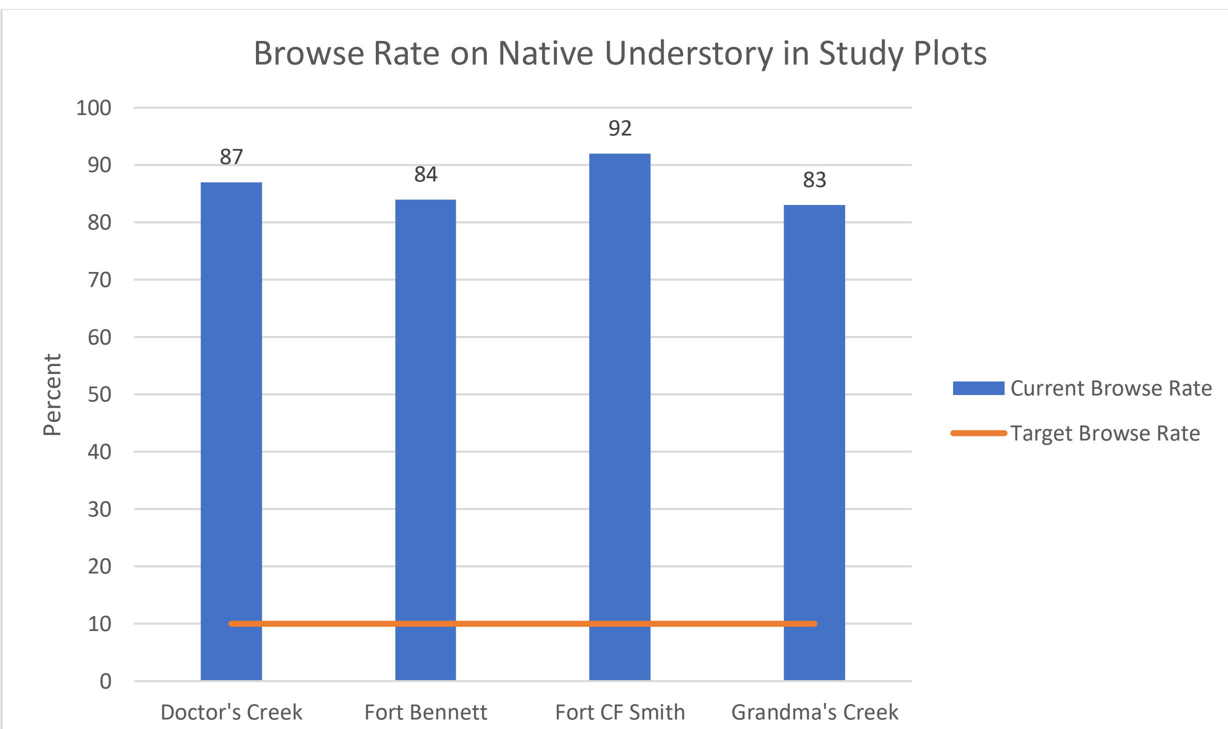


Figure 2. Mean deer browse rates on native understory in the study plots. A subjective, desired browse rate of 10% is depicted by the threshold line.

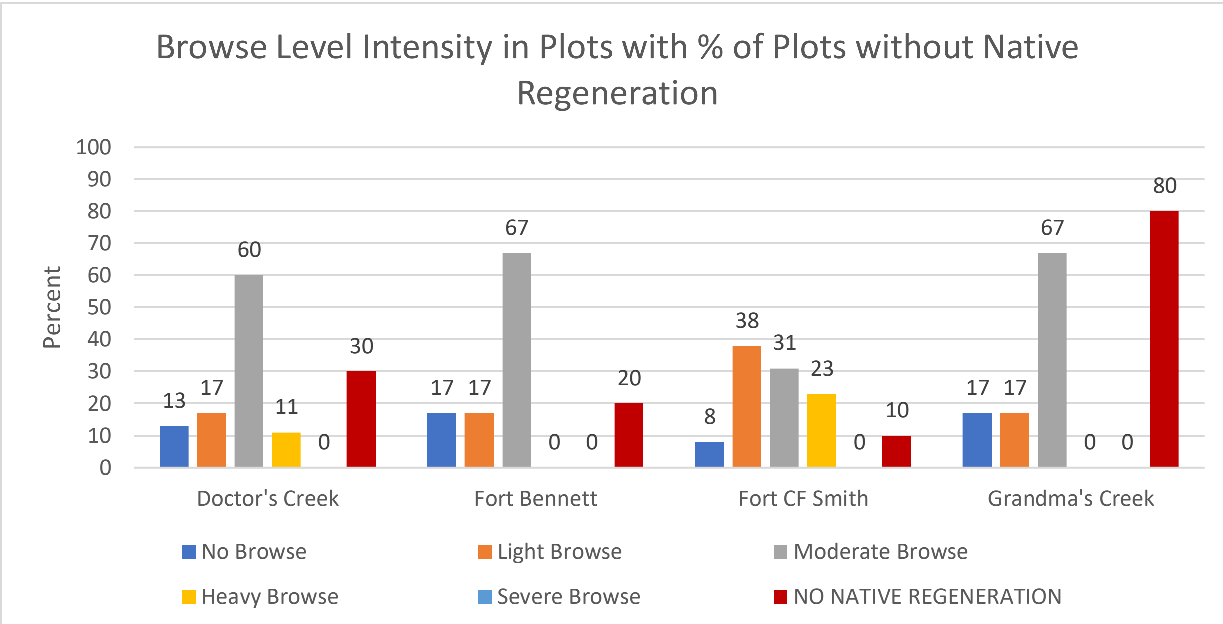


Figure 3. Full impact of deer browse and lack of native regeneration; this chart displays the data from Figure 4, below, and adds the percentage of plots that contained no native regeneration.

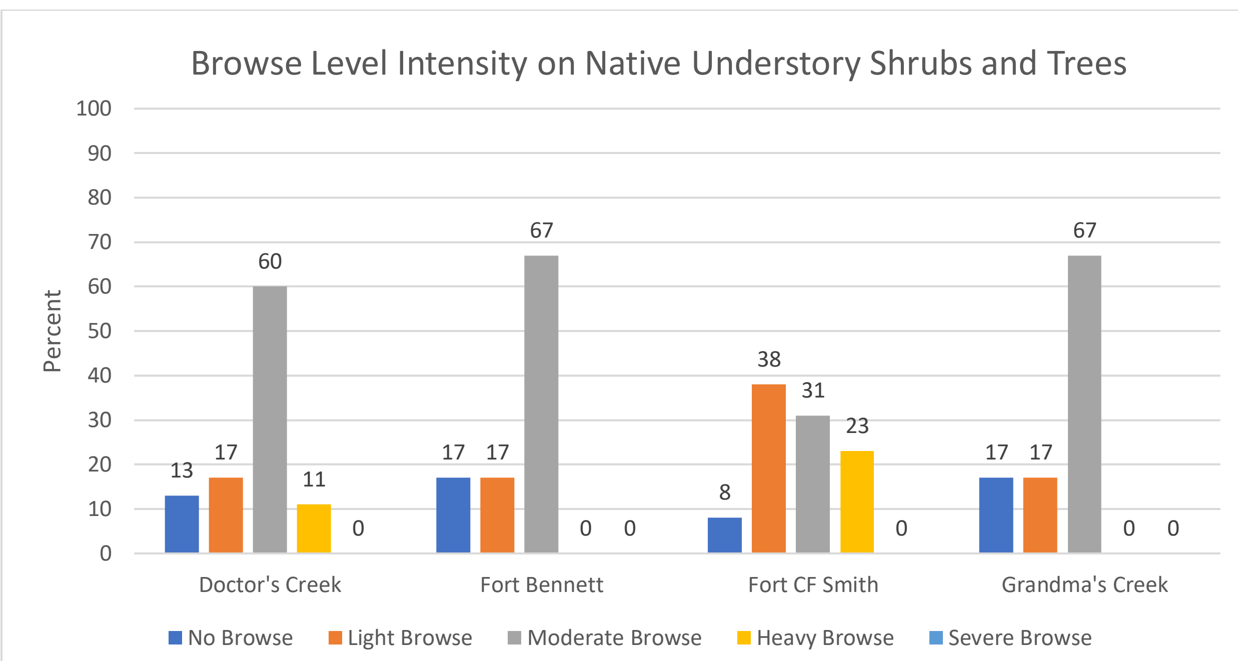


Figure 4. The percentage of browse levels on native understory vegetation that were present at each property. Deer browse was present at each property surveyed. No severe browse was recorded in the plots; however, severe browse was observed.

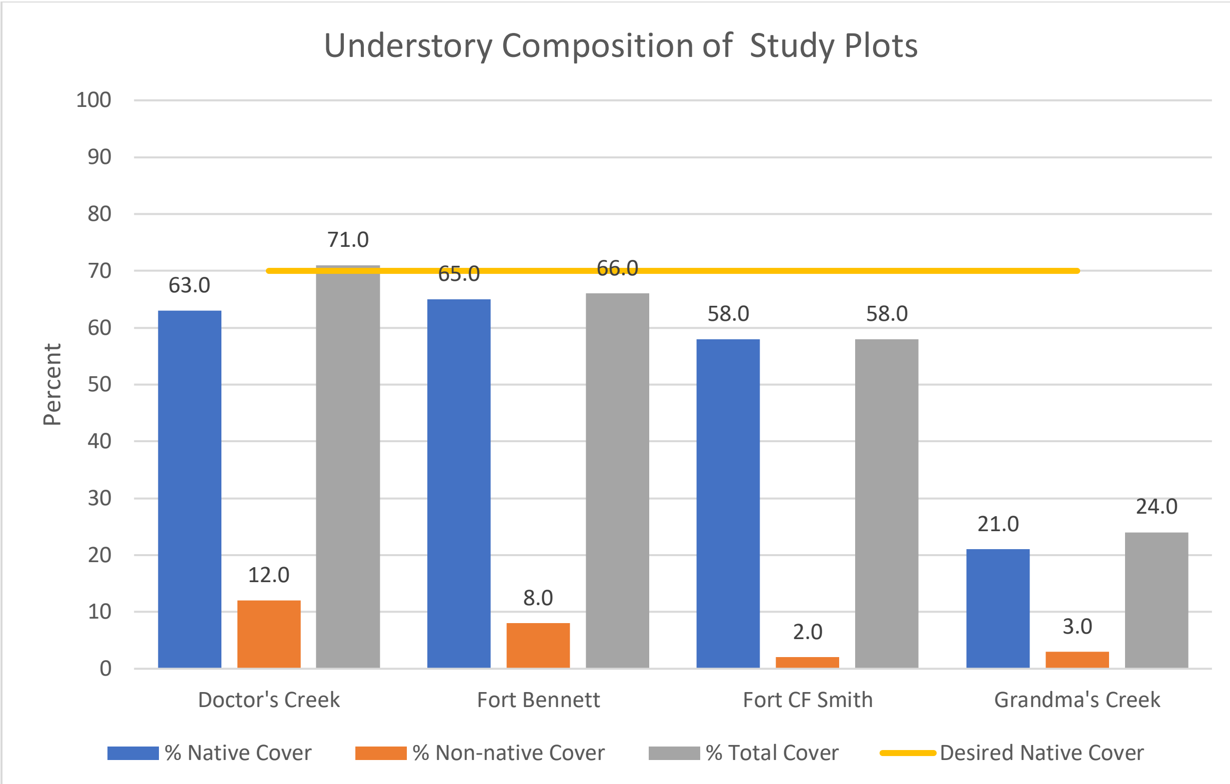


Figure 5. Using the Forest Secchi Method, the percent cover of both native and non-native cover and total vegetative cover in the understory was estimated for each study plot. This graph summarizes the percentage of secchi board cells obstructed by the three vegetation types. A subjective benchmark of 70% native species cover is represented by the threshold line.

DOCTOR'S RUN

Deer Browse on Native Understory

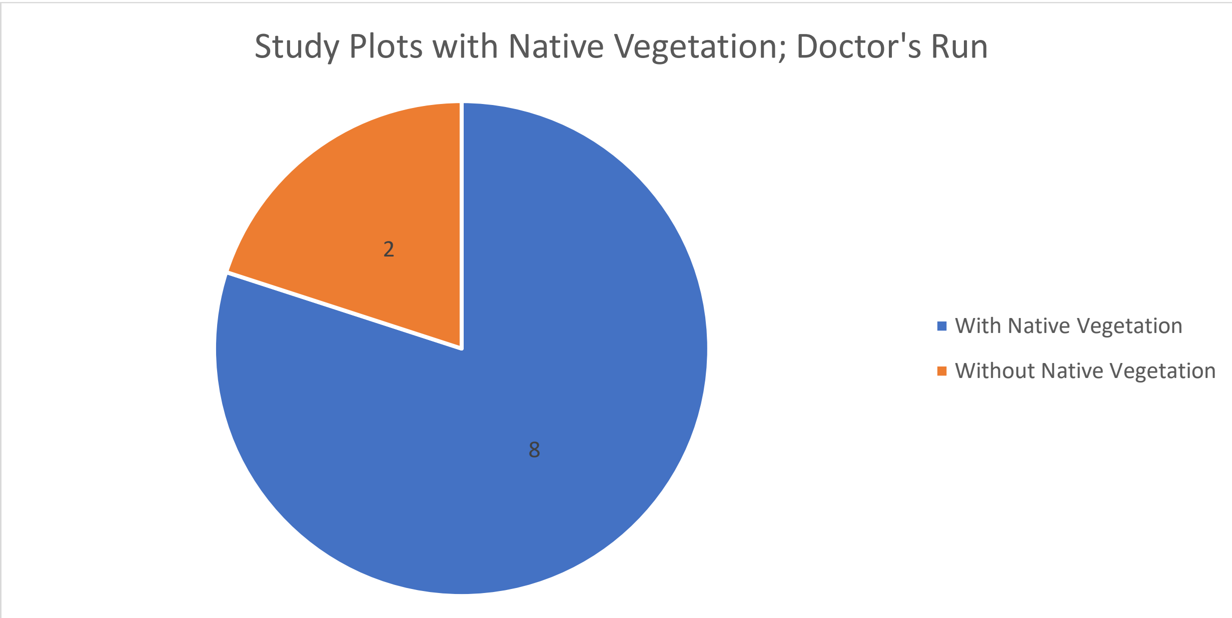


Figure 6. The percentage of randomly selected plots that contained native understory in the survey area. Eight of the ten randomly selected study plots contained native woody vegetation between 0.5' and 6.0' tall.

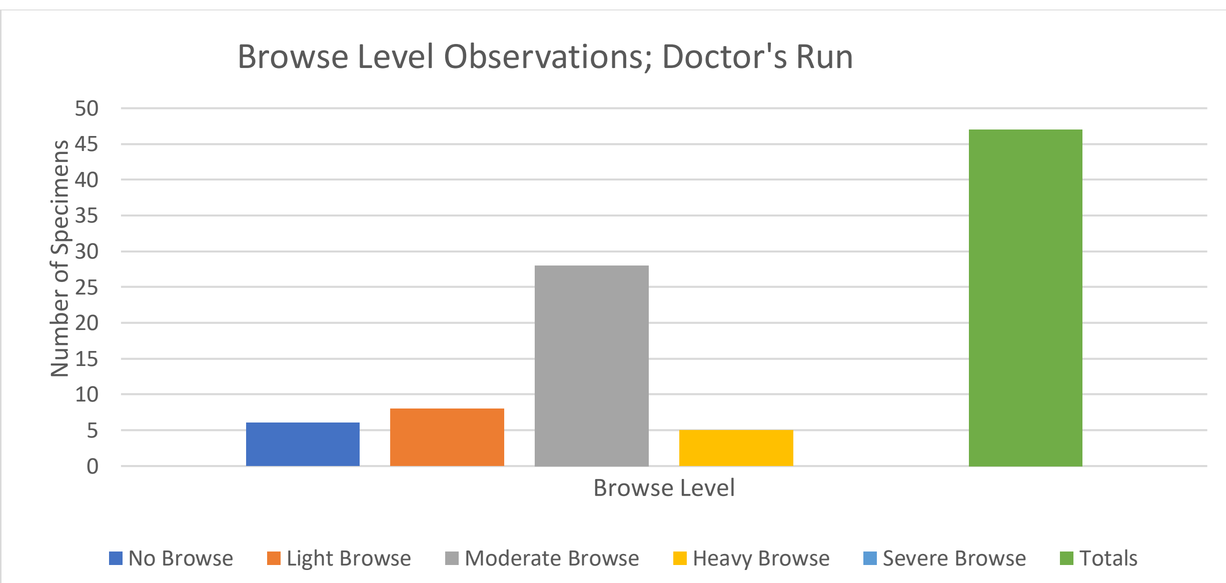


Figure 7. The total occurrences of the five characterized browse levels within the plots. In the eight study plots surveyed for deer browse intensity, 47 plants were present and surveyed. Six plants displayed no signs of browse, eight with light browse, 28 plants with moderate browse, five with heavy browse, and zero individuals displaying severe browse.

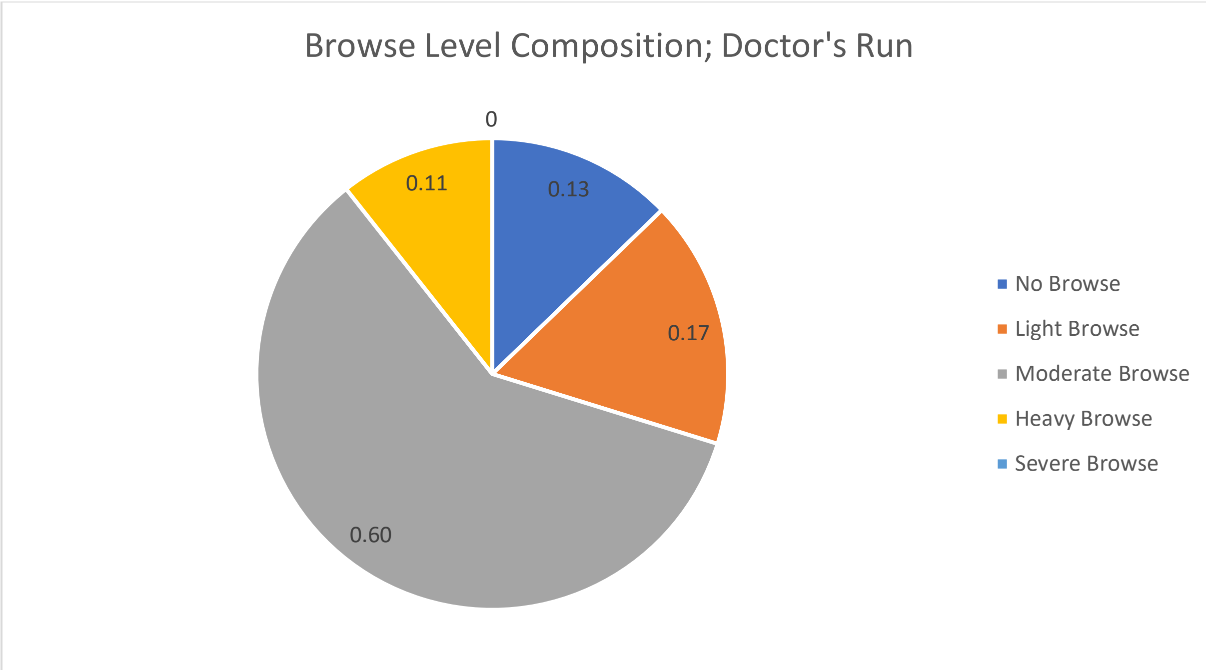


Figure 8. The percentage of browse levels represented in the study plots on this property. At Doctor's Run the majority of the browse impact level observed was moderate, where over 50% of twigs were deer browsed.

Deer Browse on Non-native Understory

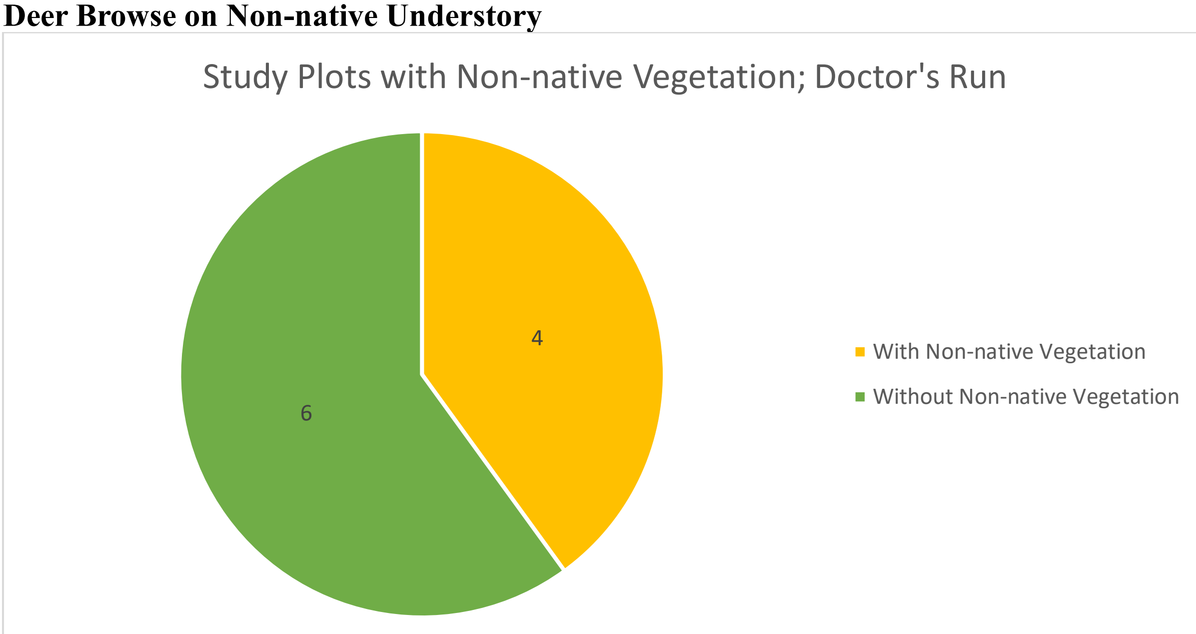


Figure 9. Presence of non-native vegetation was recorded at each study plot. At this property, non-native vegetation was present in four of the ten study plots.

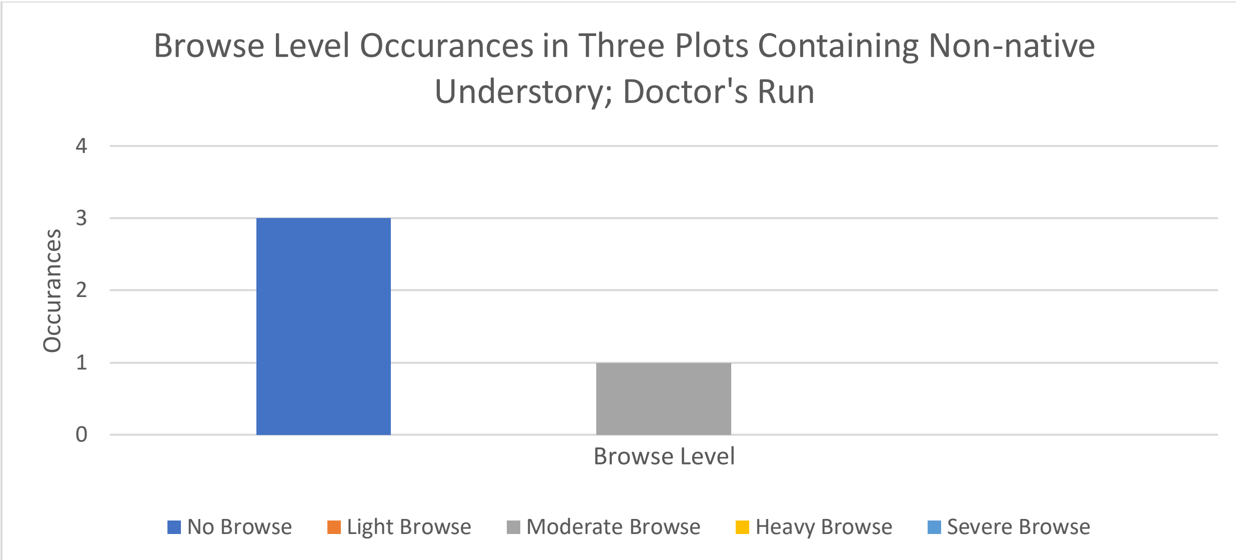


Figure 10. Presence/absence of the five characterized browse levels was recorded for plots that contained non-native vegetation. Three study plots contained non-native understory. No browse was present in three plots; moderate browse was present in one plot.

Dominant Species Data

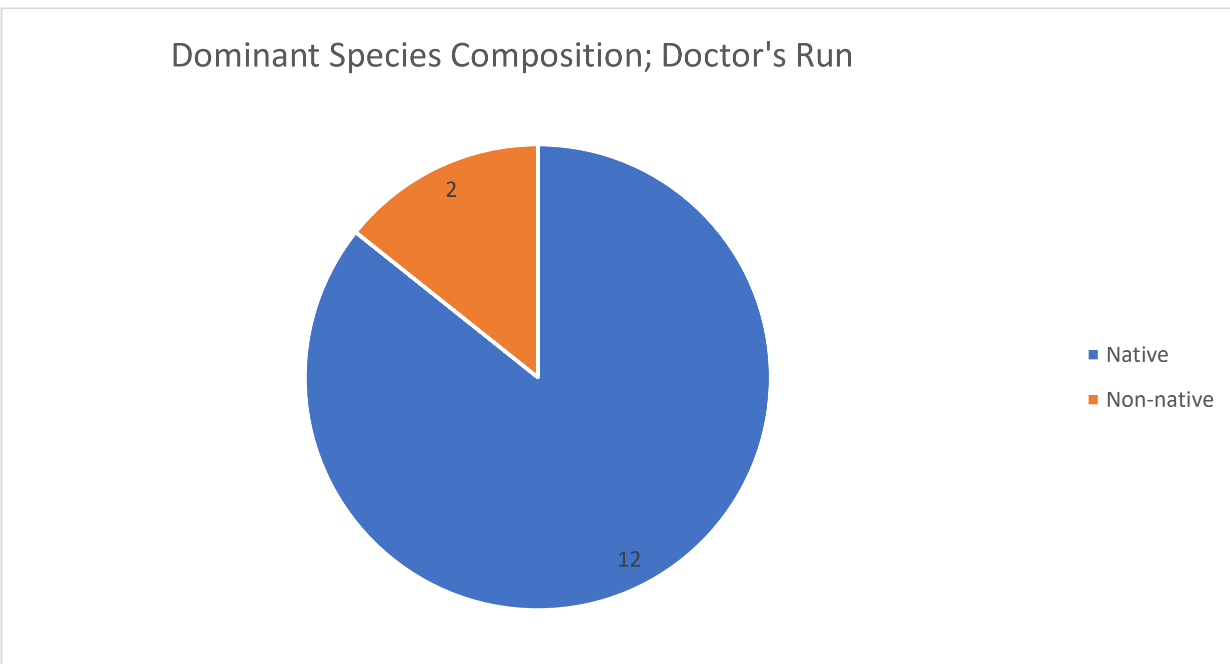


Figure 11. Dominant understory species within the study plots were recorded. A maximum of four species were listed for each site. At Doctor's Run 12 of the 14 recorded species occurrences were native.

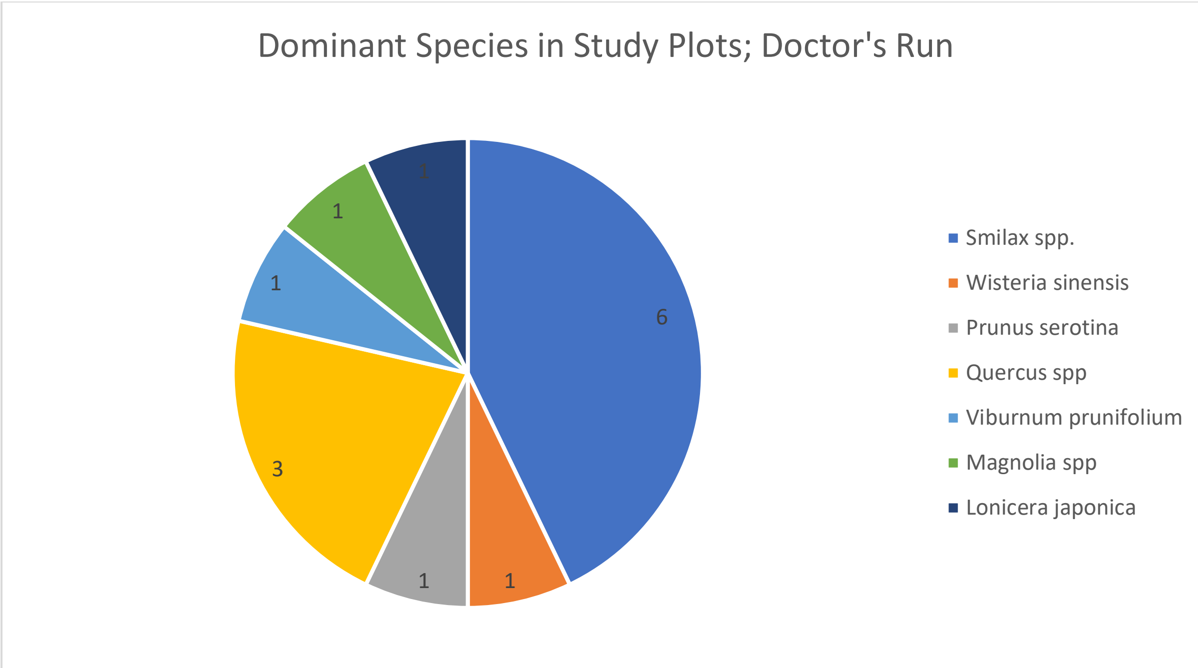


Figure 12. All dominant understory species and their total occurrences within the ten study plots. *Smilax* spp. was the most common dominant species at this location, occurring as a dominant species in six of the study plots.

Understory Composition

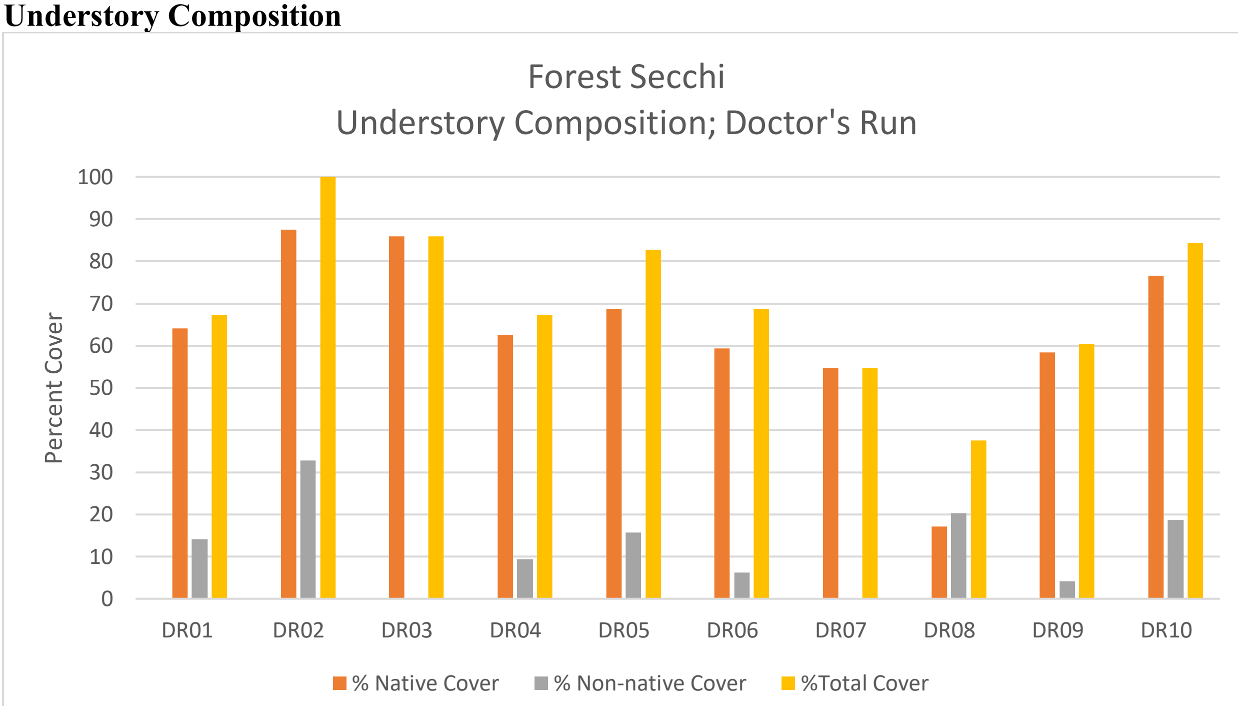


Figure 13. A forest secchi board was used to measure the percent cover of native species, invasive species, and total plant cover at the cardinal points of each study plot.

<u>Fort Bennett</u>

Deer Browse on Native Understory

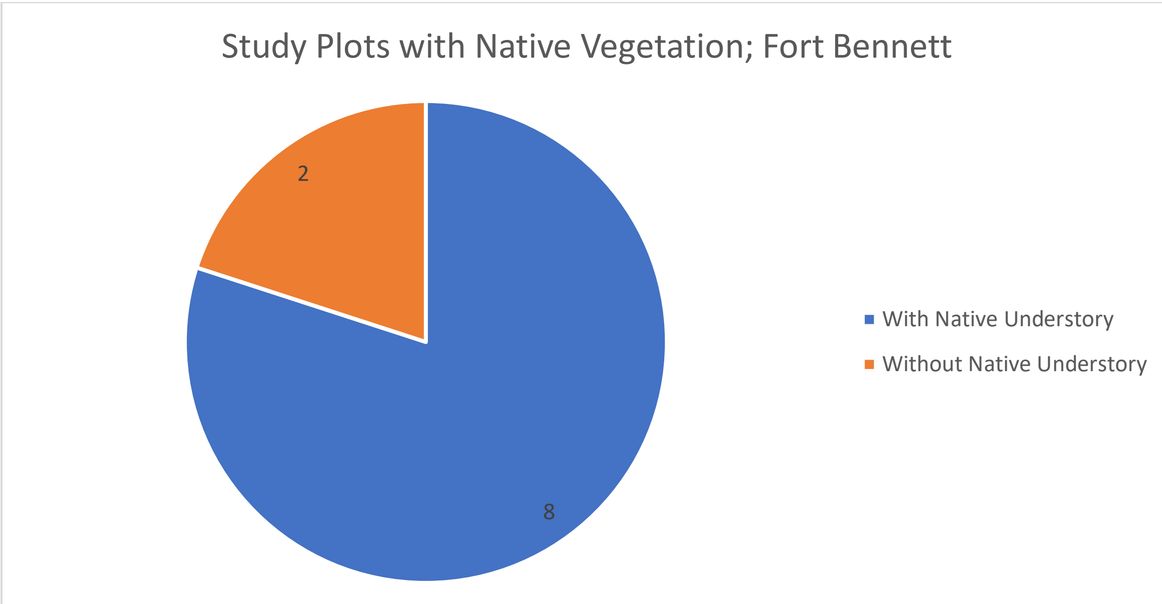


Figure 14. The percentage of randomly selected plots that contained native understory in the survey area. Eight of the ten randomly selected study plots contained native vegetation in the understory.

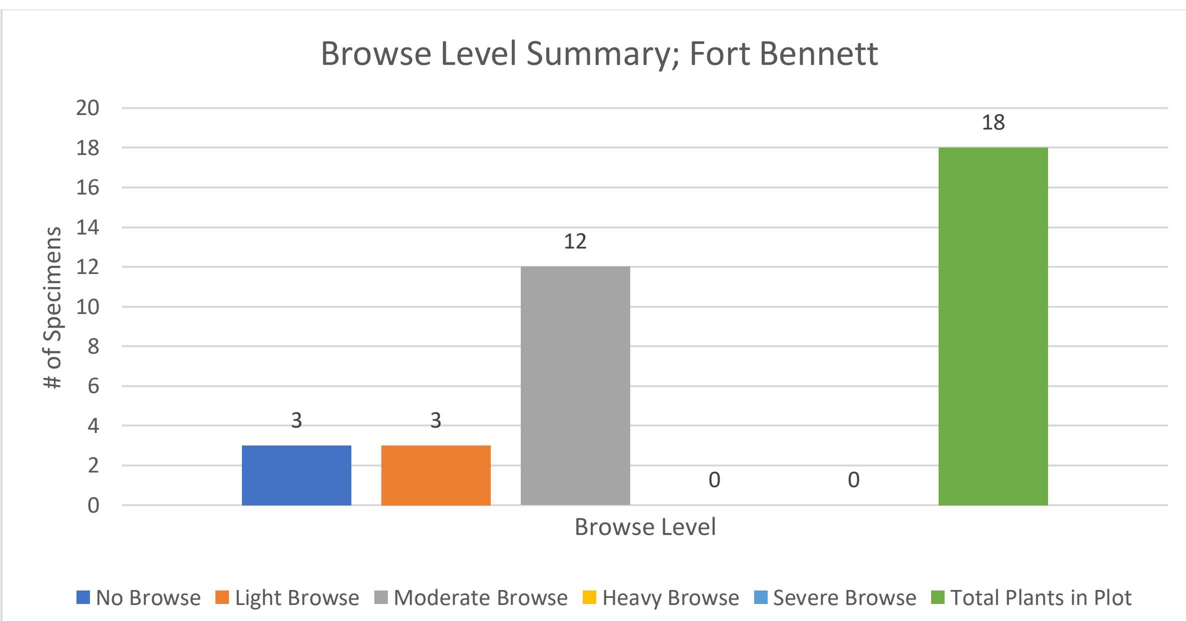


Figure 15. The total occurrences of the five characterized browse levels within the plots. Within the eight study plots surveyed for deer browse intensity, 18 plants were surveyed. Three plants displayed no signs of browse, three with light browse, 12 plants with moderate browse, zero with heavy browse, and zero individuals displaying severe browse.

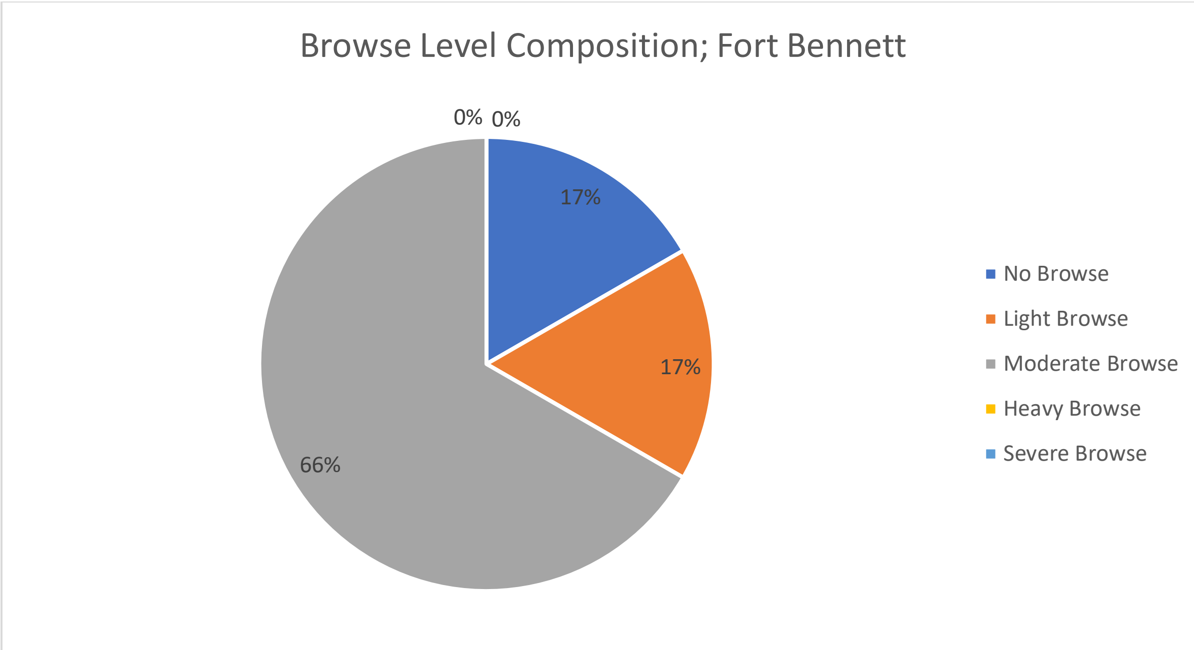


Figure 16. The percentage of the browse levels represented in the study plots on this property. At Fort Bennett, 17% of the plants in the study plots were not browsed, 17% displayed light browse, 66% displayed moderate browse, while there were no heavy or severe browse level plants in the plots.

Deer Browse on Non-Native Understory

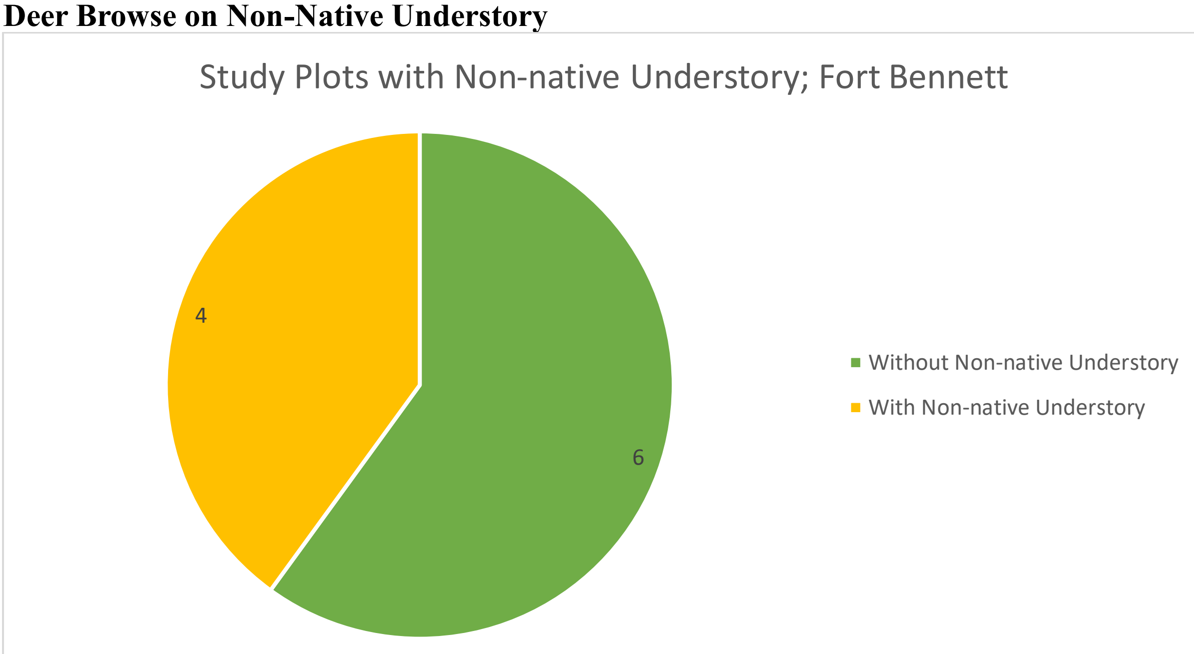


Figure 17. Presence of non-native vegetation was recorded at each study plot. Four of the ten plots contained invasive species in the understory.

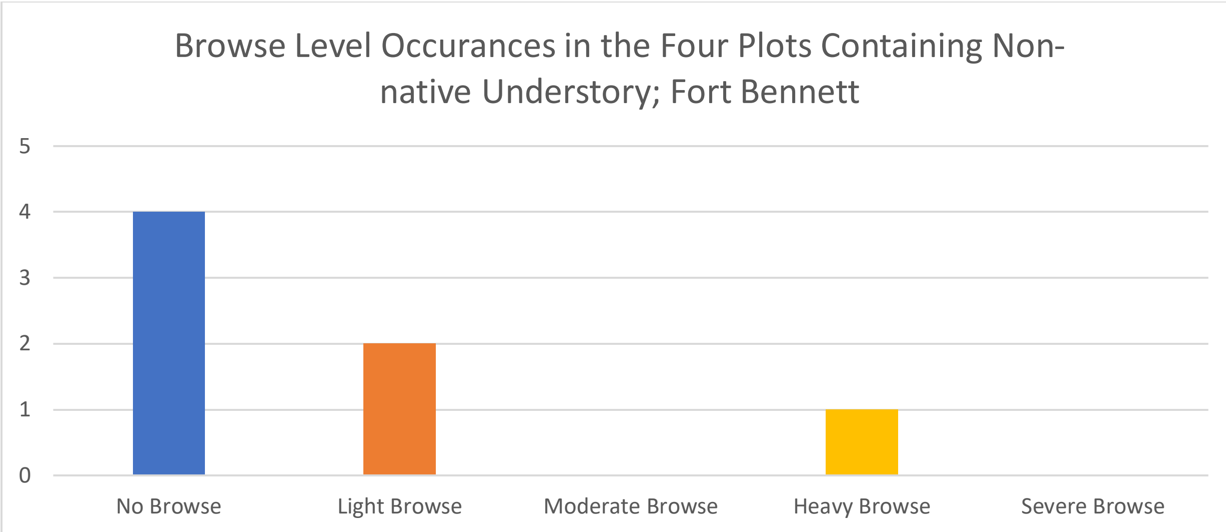


Figure 18. Presence/absence of the five characterized browse levels was recorded for plots that contained non-native vegetation. Within the four plots measured for the presence and absence of browse on invasive understory, plant(s) with no browse was observed in four plots, light browse was represented in two plots, and heavy browse was observed in only one plot.

Dominant Species Data

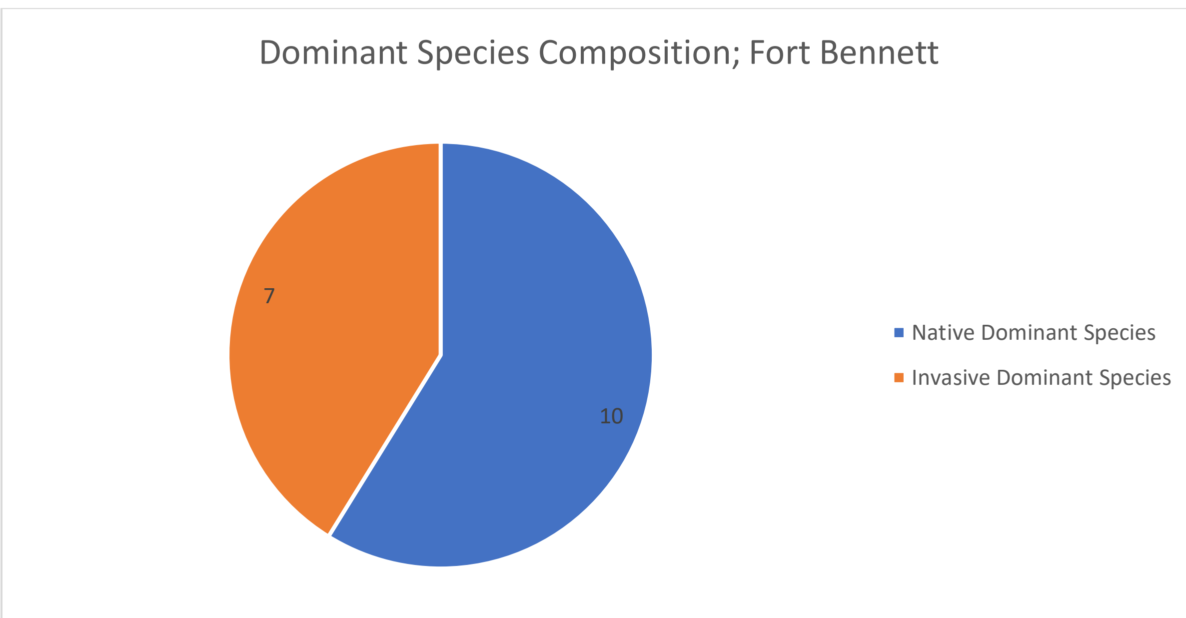


Figure 19. Dominant understory species within the study plots were recorded. Of the dominant species observed in the study plots, 59% of the species were native.

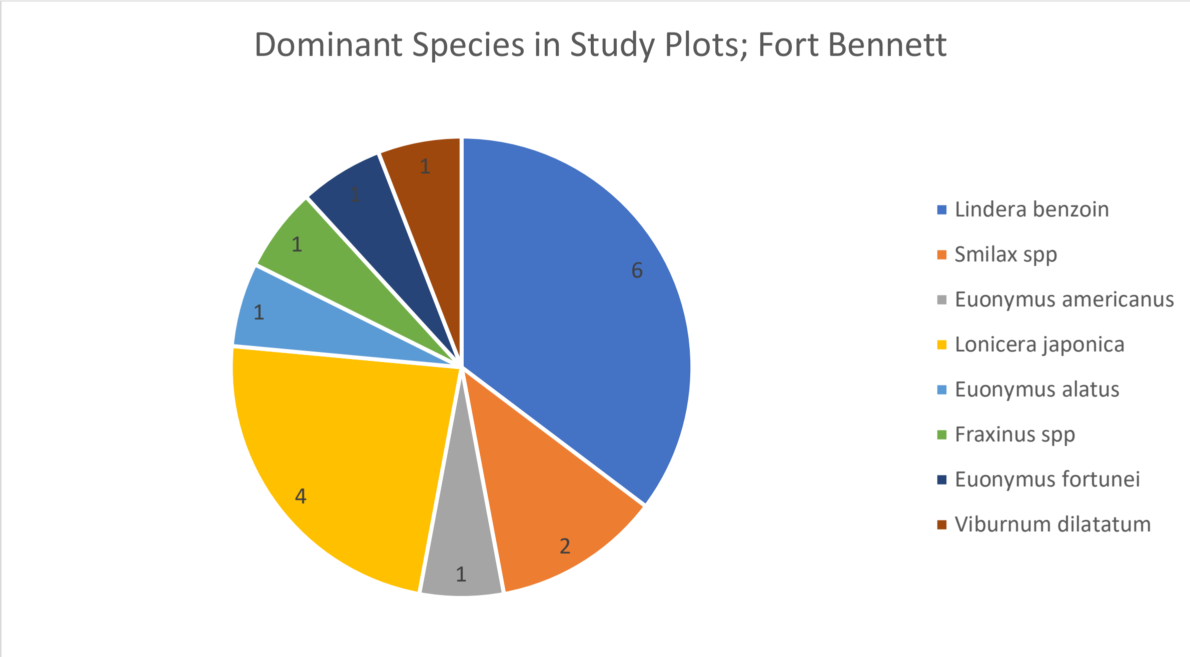


Figure 20. All dominant understory species and their total occurrences within the ten study plots. At Fort Bennett, *Lindera benzoin* was the most represented dominant species, this plant is consumed by white-tailed deer but is not a preferred species. *Lonicera japonica* was also observed as a dominant species in four of the 10 study plots.

Understory Composition

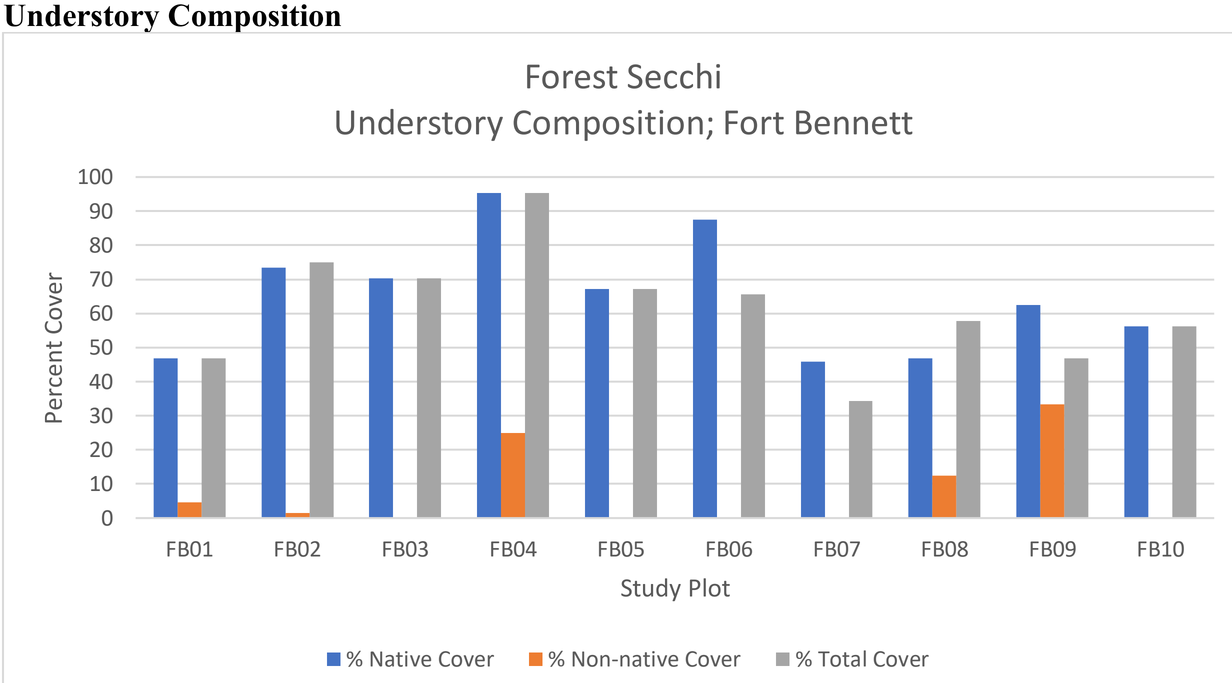


Figure 21. A forest secchi board was used to measure the percent cover of native species, invasive species and total plant cover at the cardinal points of each study plot. Research suggests that 70% vegetative cover in the understory is ideal for forest regeneration.

Fort C.F. Smith

Deer Browse on Native Understory

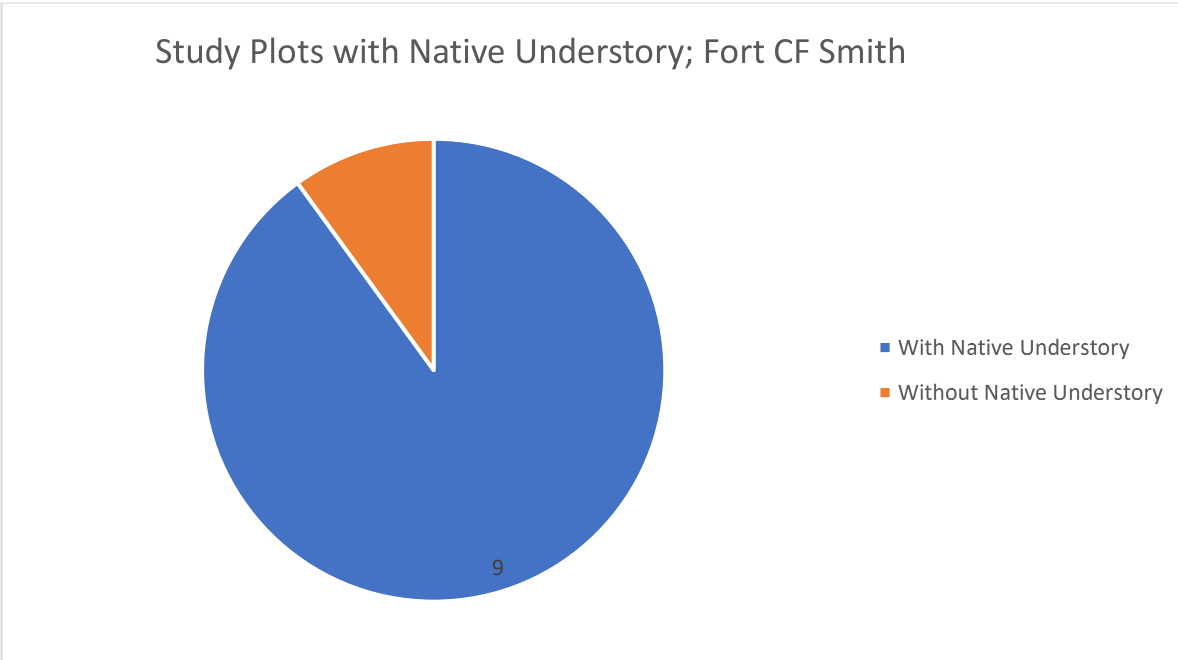


Figure 22. The percentage of randomly selected plots that contained native understory in the survey area. Nine of the ten randomly selected sites for this location contained woody native species in the study plots.

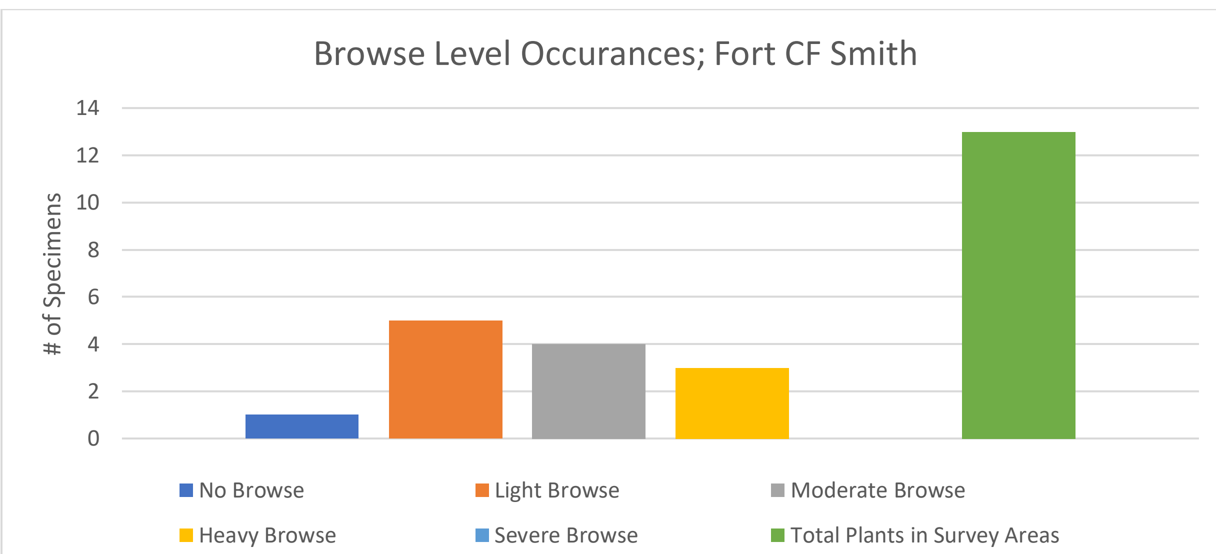


Figure 23. The total occurrences of the five characterized browse levels within the plots. Within the nine study plots surveyed for deer browse intensity, 13 plants were surveyed. One plant displayed no signs of browse, five with light browse, four plants with moderate browse, three with heavy browse, and zero individuals displaying severe browse.

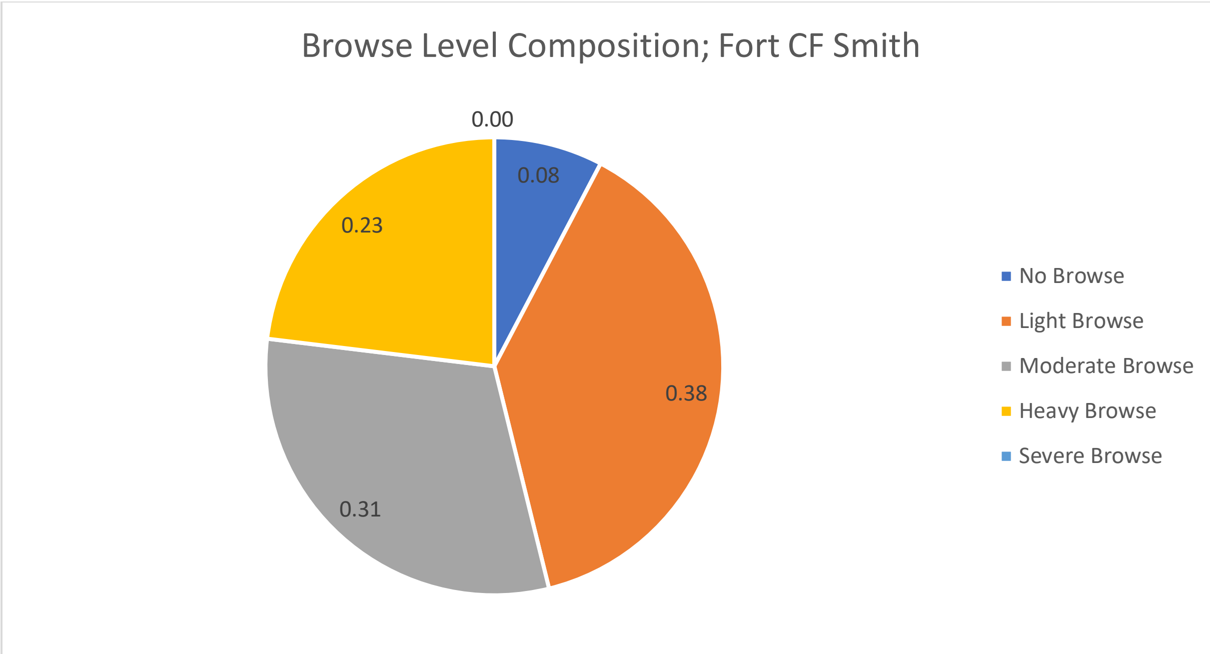


Figure 24. The percentage of the browse levels represented in the study plots on this property. Within the study plots, 8% of native plants were not browsed, 38% of native plants displayed light browse, 31% displayed moderate browse, and 23% displayed heavy browse impact.

Deer Browse on Non-native Understory

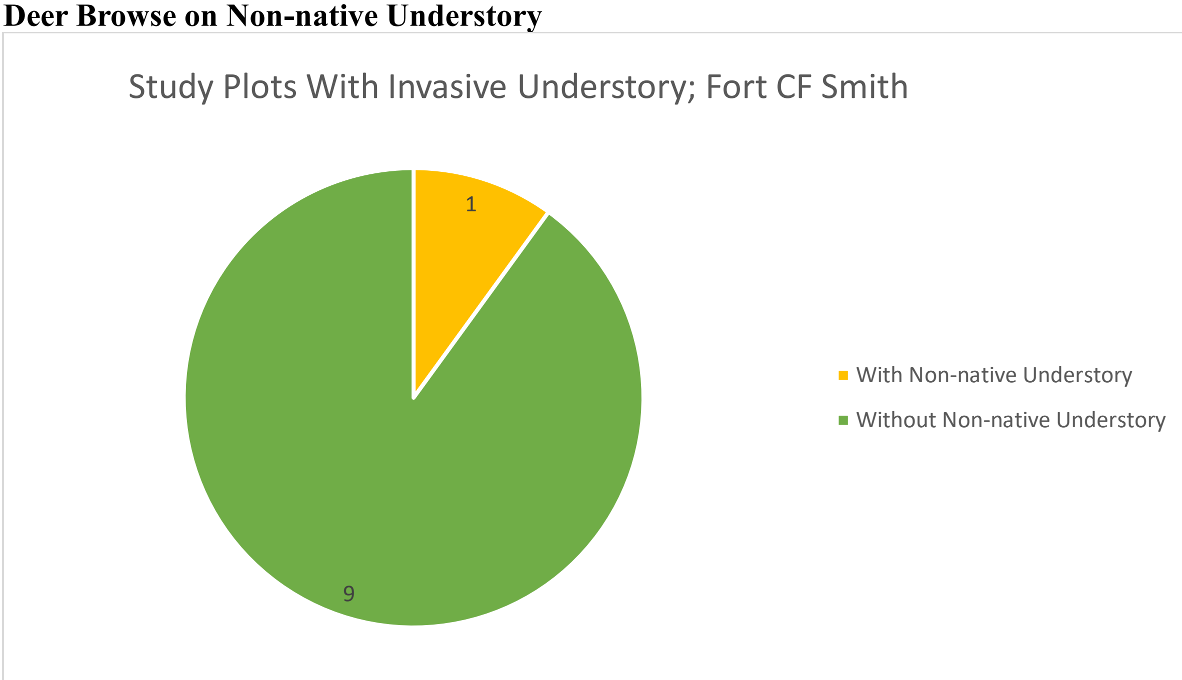


Figure 25. Presence of non-native vegetation was recorded at each study plot. One of the study plots contained non-native species in the understory.

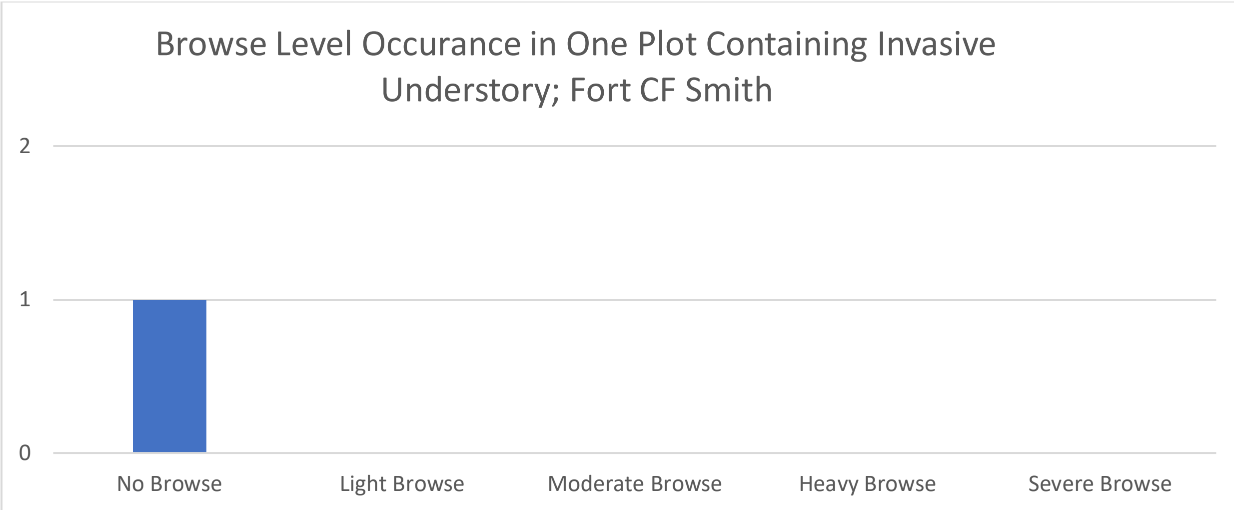


Figure 26. Presence/absence of the five characterized browse levels was recorded for plots that contained non-native vegetation. In the single plot with invasive species in the study area, only the no browse impact level was present.

Dominant Species Data

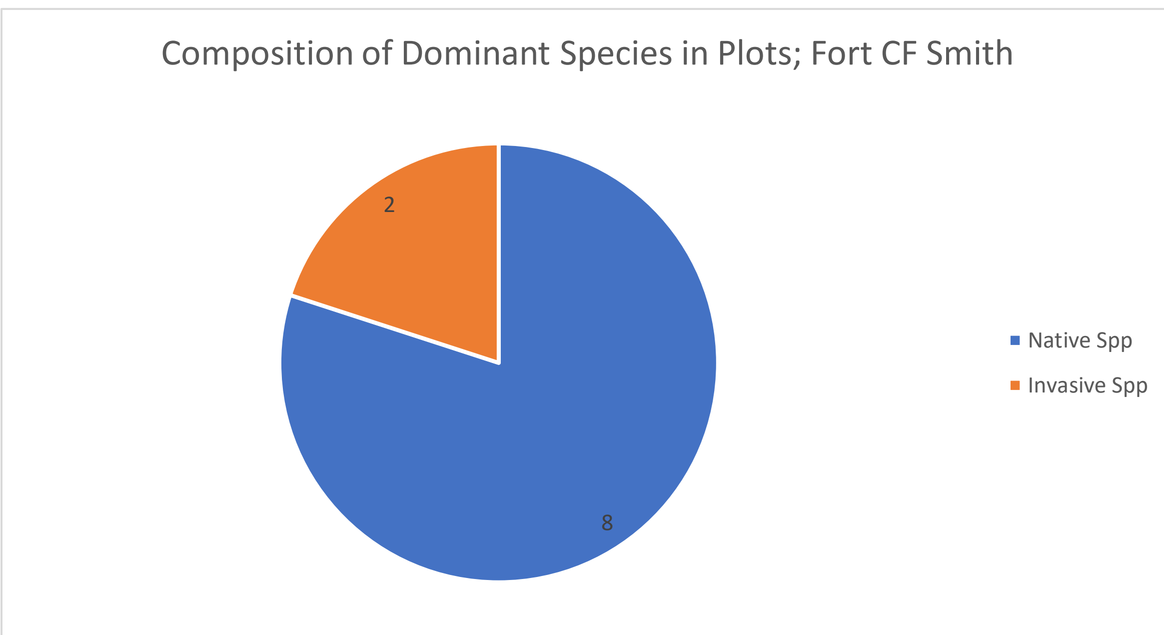


Figure 27. Dominant understory species within the study plots were recorded. A total of 10 species were recorded as dominant in the understory of the study plots. Of the ten recorded species, 80% of them were native.

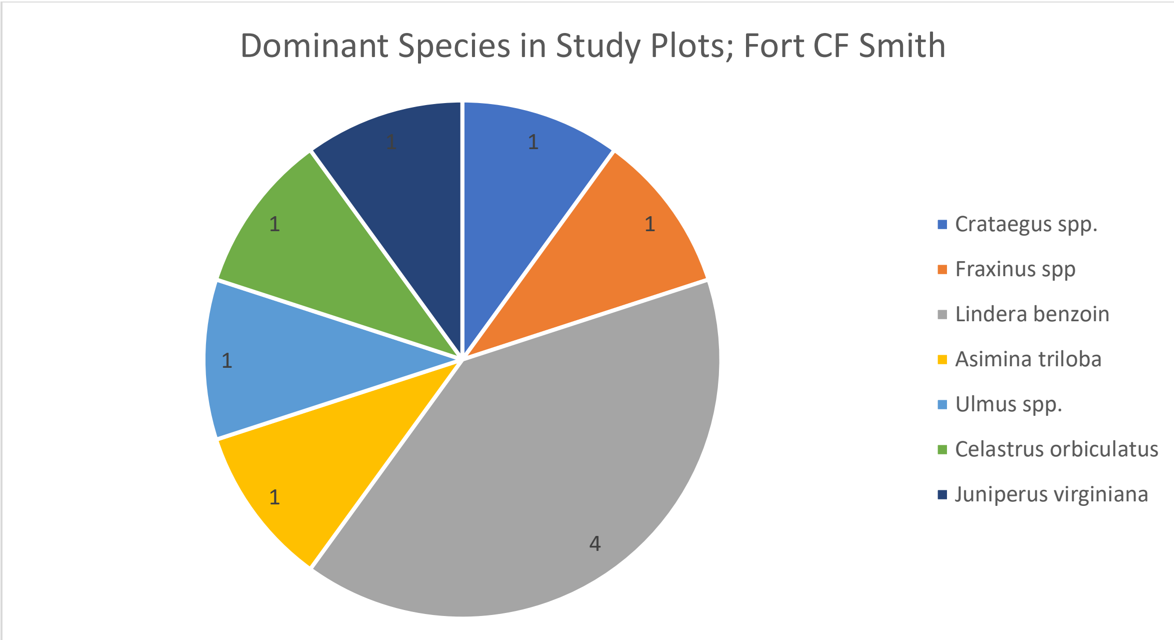


Figure 28. All dominant understory species and their total occurrences within the ten study plots. At Fort CF Smith, the most represented dominant species in the understory was *Lindera benzoin*, a native shrub, but not a preferred browse plant for white-tailed deer.

Understory Composition

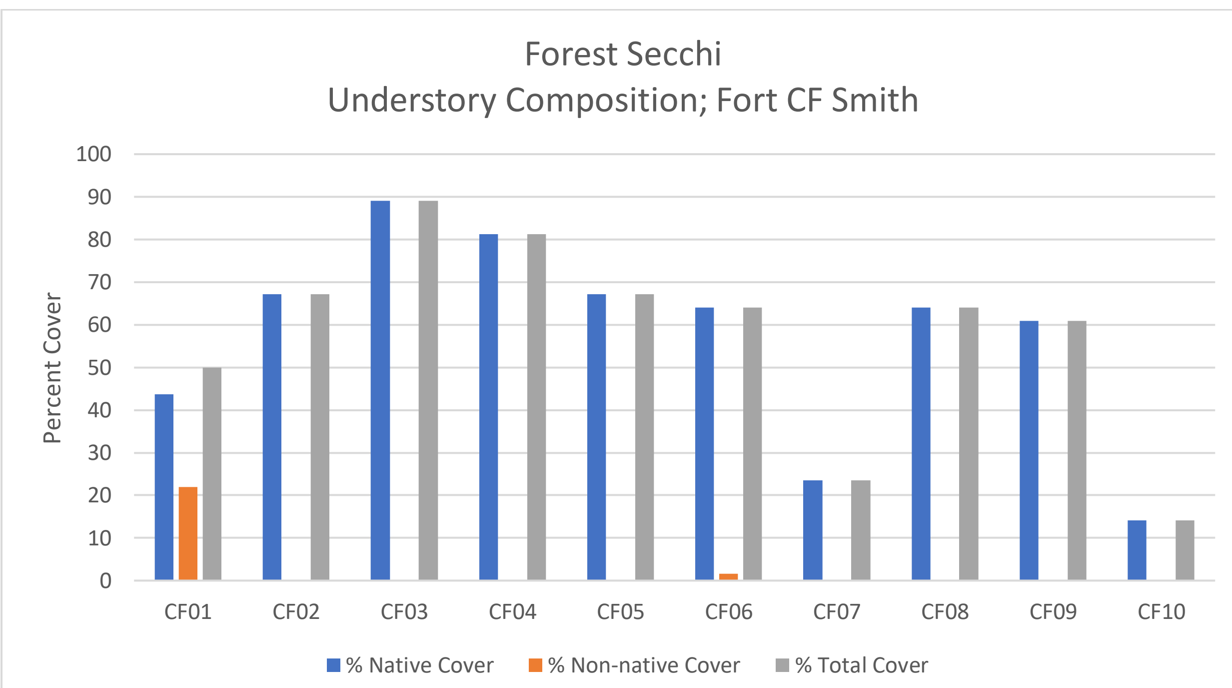


Figure 29. The Forest Secchi Method was utilized to measure the composition of native species and invasive species in the understory. Total vegetative cover in the understory was also measured with this methodology.

Grandma's Creek

Deer Browse on Native Understory

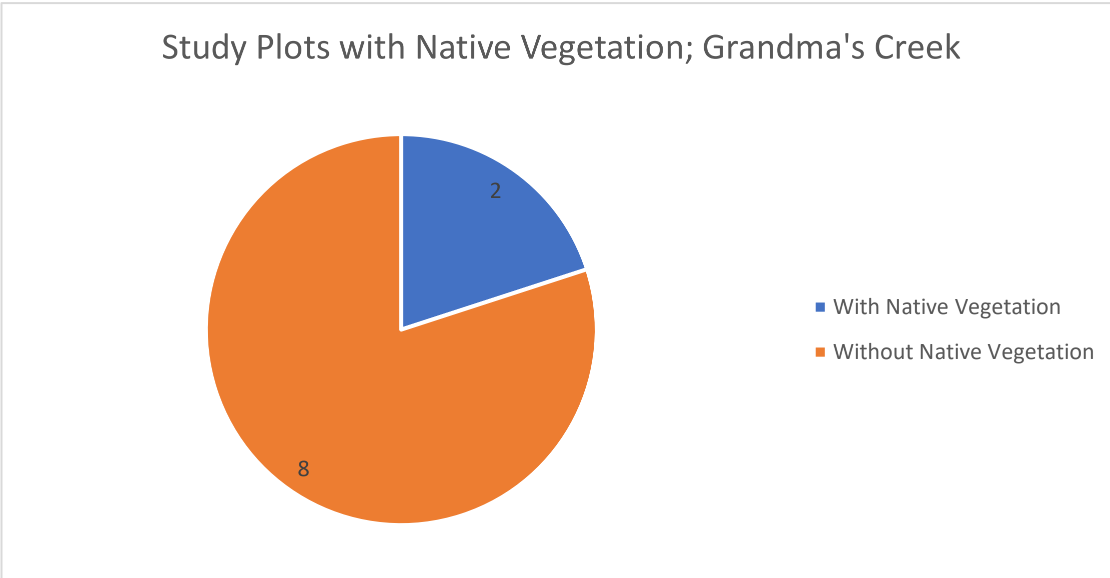


Figure 30. The percentage of randomly selected plots that contained native understory in the survey area. Within Grandma's Creek two of the 10 randomly selected study plots contained native woody species in the understory.

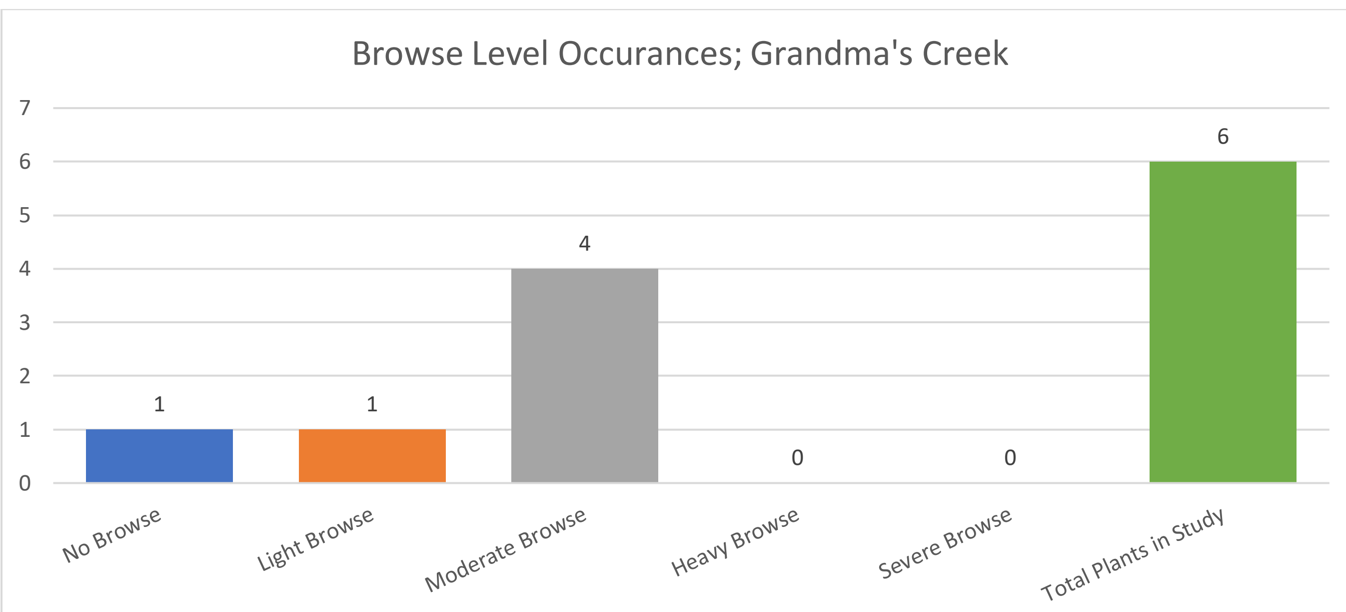


Figure 31. The total occurrences of the five characterized browse levels within the plots. In the eight study plots surveyed for deer browse impact levels, a total of six plants were observed. One of these specimens displayed no browse impact, one plant displayed light browse impact, and four plants displayed moderate browse impact. Heavy and severe browse impact was not observed in the study plots at Grandma's Creek.

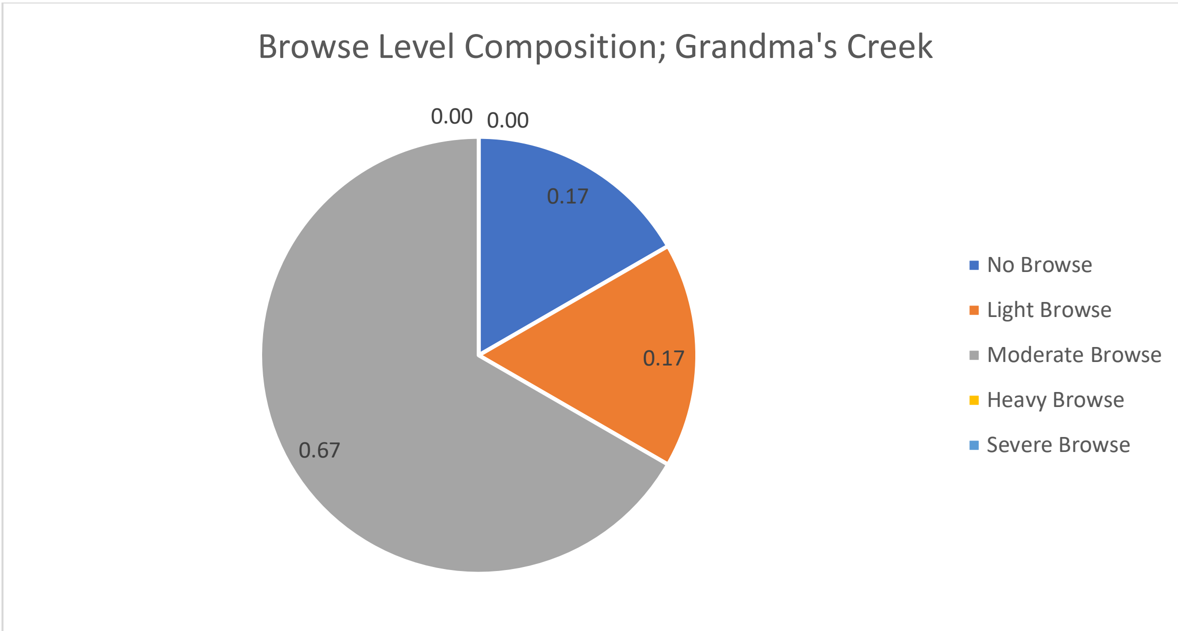


Figure 32. The percentage of the browse levels represented in the study plots on this property. Within the study plots, 17% of native plants were not browsed, 17% of native plants displayed light browse, and 67% displayed moderate browse.

Deer Browse on Non-native Understory

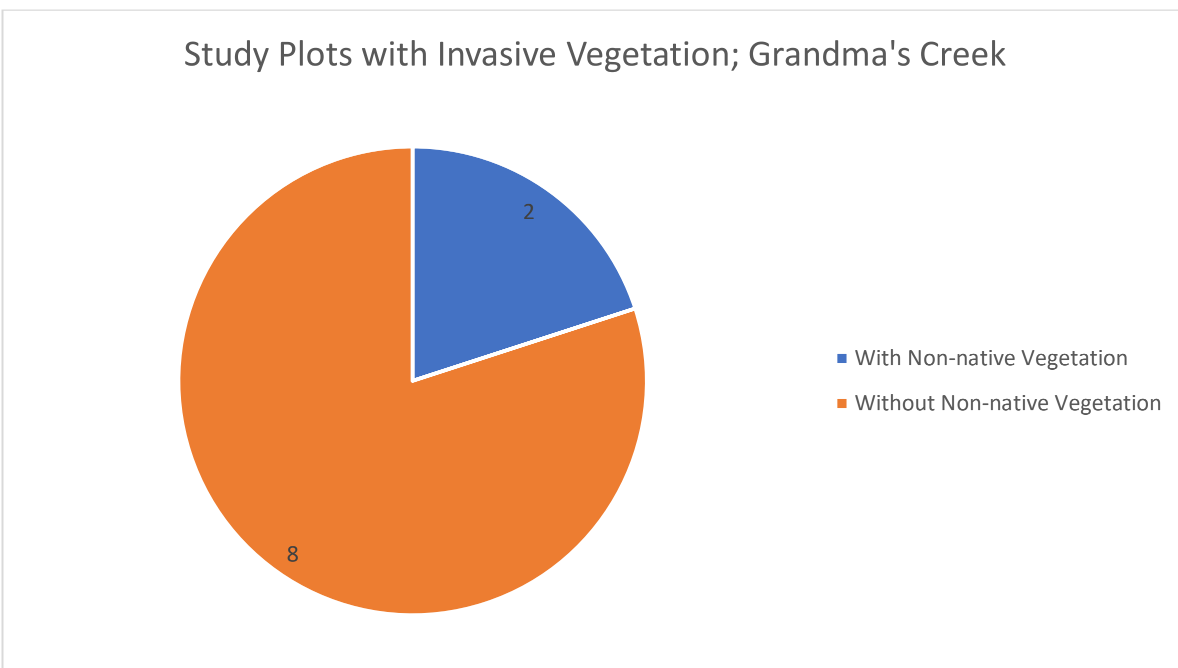


Figure 33. Presence of non-native vegetation was recorded at each study plot. Two of the 10 randomly selected study plots had invasive species in the understory.

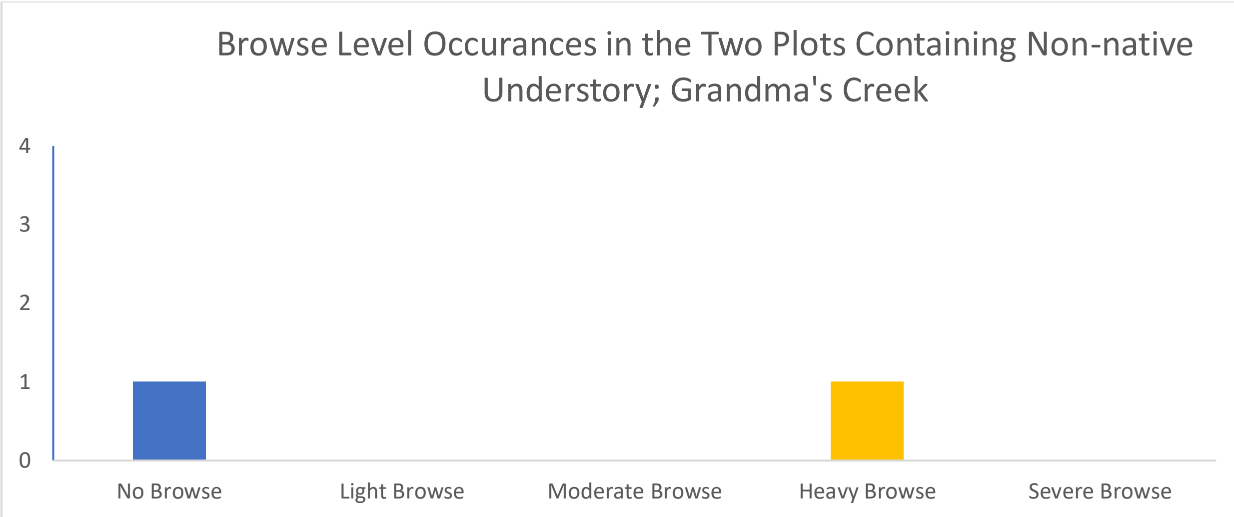


Figure 34. Presence/absence of the five characterized browse levels was recorded for plots that contained non-native vegetation. Within the two plots with non-native understory, the no browse impact level was present once and the heavy browse impact level was present once.

Dominant Species Data

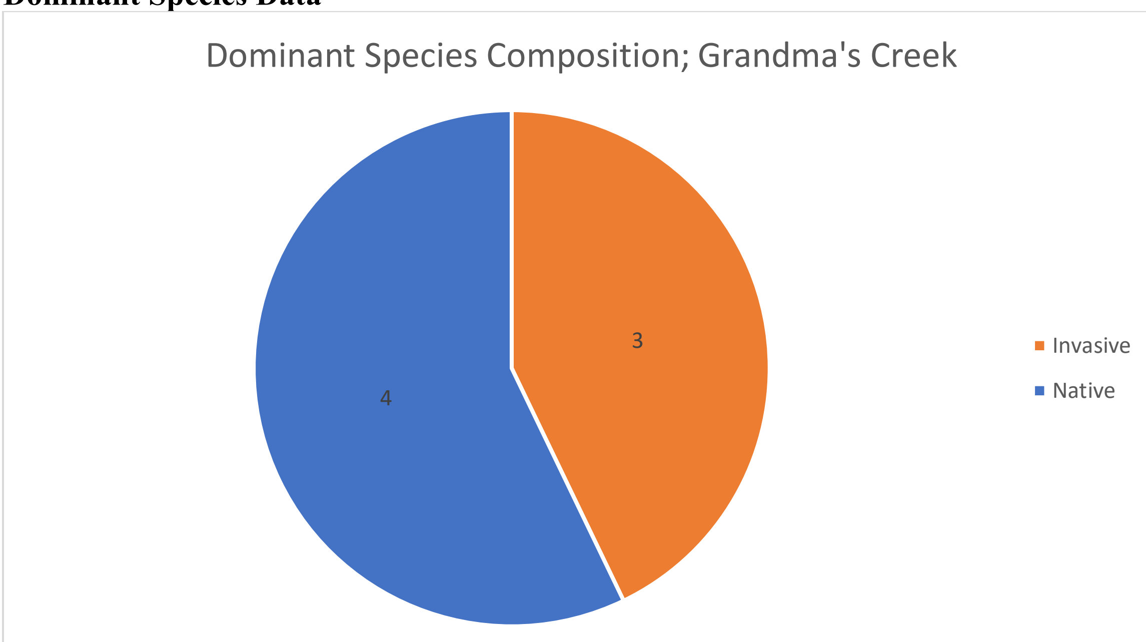


Figure 35. Dominant understory species within the study plots were recorded. Of the dominant species recorded in the study plots, 57% of the observations were of native species.

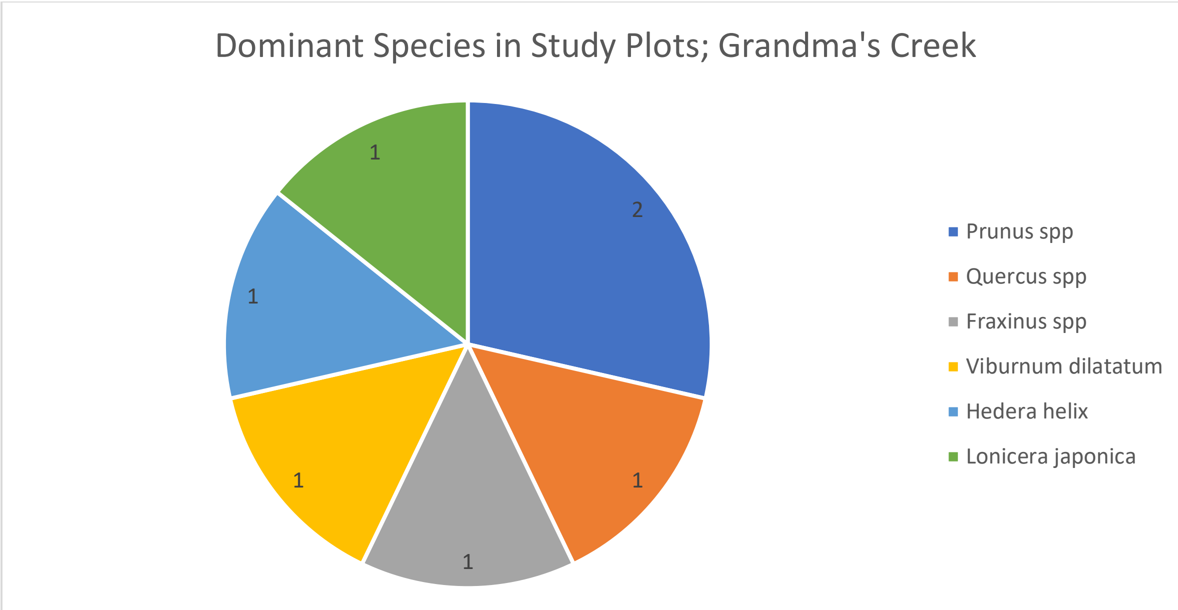


Figure 36. All dominant understory species and their total occurrences within the ten study plots. In the study plots at this location, *Prunus* spp. was the dominant species in two plots, while the remainder of the species listed were represented once each throughout the 10 study plots.

Understory Composition

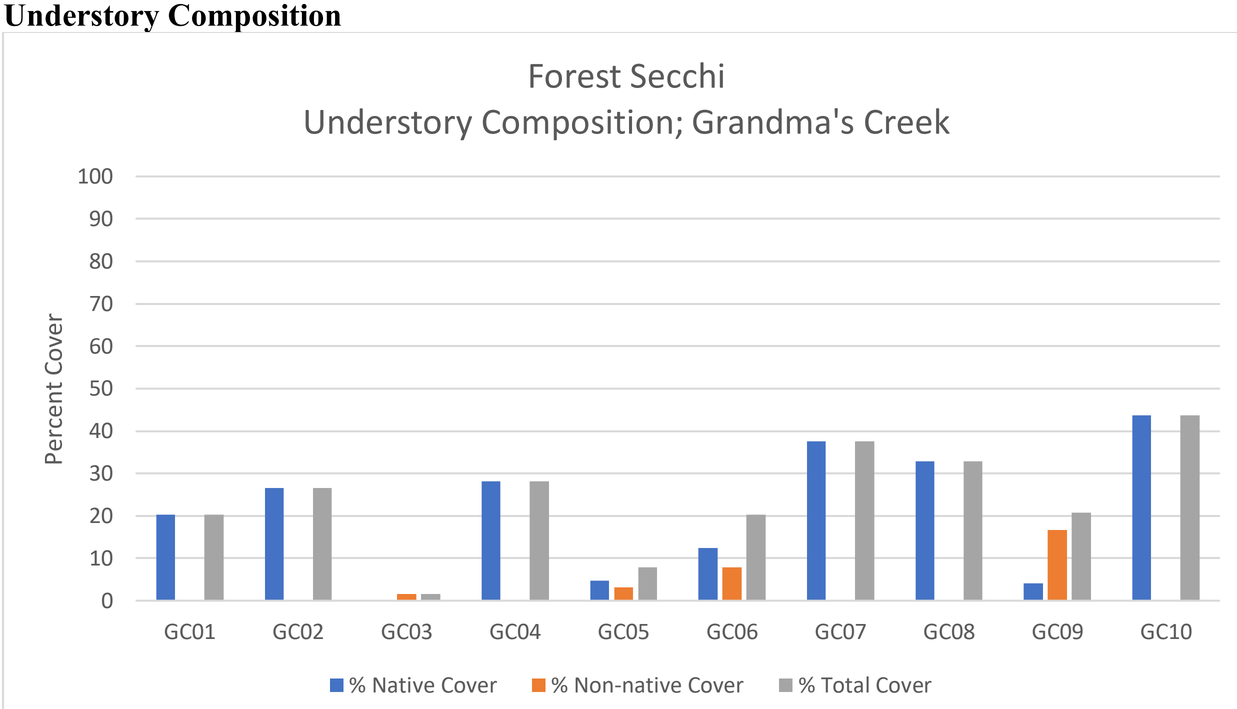


Figure 37. The Forest Secchi Method was utilized to measure the composition of native species and invasive species in the understory. Total vegetative cover in the understory was also measured with this methodology. At Grandma's Creek, native vegetative cover and total vegetative cover were the lowest of all four sites studied. Research suggests 70% vegetative cover in the understory is needed to promote forest regeneration.