BAY RIDGE CIVIC ASSOCIATION

FINAL FOREST ASSESSMENT REPORT

Prepared for:

Bay Ridge Civic Association

80 E. Lake Drive

Annapolis, MD 21403

Prepared by:

Environmental Systems Analysis, Inc.

162 West Street

Annapolis, MD 21401

September 2012

Modification March 2013

Table of Contents

EXECUTIVE SUMMARY

The Bay Ridge Civic Association (BRCA), which owns Bay Ridge Forest (the Forest), desires a benchmark inventory of the various plants, wildlife, and soils that exist in the two main areas of the Forest in order to inform future management and stewardship. Environmental Systems Analysis, Inc. was tasked with surveying the underlying tree, shrub, and ground layer plants of the Forest; quantitatively and qualitatively surveying and documenting the vegetative species for a plant inventory of the Forest; observing wildlife and signs of wildlife within the Forest; and surveying the soils type and conditions within the Forest. We followed Maryland's Natural Resource Inventory and Forest Stand Delineation methodology to document the forest conditions.

The Forest is a mature forest stand in fair condition with substantial invasive species cover in its groundcover and vine layers. It provides habitat for wildlife and birds, as evidenced through the wildlife camera, observations in the field and previous bird surveys. It also provides a place for recreation and environmental education for community members. A USDA deer count study indicates that there are 36-42 deer in the community. It appears the deer population is above the ecological carrying capacity of the forest.

We recommend managing deer and invasives together to benefit the forest health. Below is a list of our recommendations:

- Adopt a Deer Management strategy
- Adopt a Invasive Species Management strategy
- Conduct a formal vegetation study of the deer exclosures.
- Assess the riser pipe of Herndon Pond for structural soundness and consider digging the pond deeper.
- Remind neighbors not to dump yard waste in the Forest, keep dogs on leashes when in the Forest, and keep cats indoors.
- Limit trails to those already established rather than allow residents to create new trails.
- Conduct an annual boundary survey for hazardous trees and encroachments.
- Allow dead snags to remain when not presenting a threat to persons or property.

GLOSSARY

Adventitious – arising or occurring sporadically or in other than the usual location. Adventitious plants may be native and indigenous to the United States or Maryland, but not necessarily endemic or local to the Western Shore Coastal Plain.

Coppice – to cut back woody vegetation repeatedly, which creates multiple short stems, a typical observed phenomenon where deer densities may be high.

DBH – diameter at breast height, which is defined as 4.5 feet above the ground.

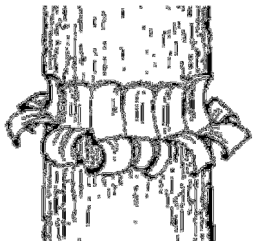
Depauperate – having few nutrients, resulting in poor growth, a term often used to describe soil that has a shallow, exhausted top-soil horizon.

Epicormic sprout – a shoot or branch that is usually suppressed by hormones but grows under certain conditions, such as when damage occurs to higher parts of the plant or light levels are increased because competing plants are removed.

Forb – flowering herbaceous plant that is not a grass, sedge or rush

Forest Data Station – point where data is collected for the Forest Study

Frilling – a method of killing trees with herbicide by cutting into the bark around the entire circumference of the tree trunk and immediately applying herbicide into the cuts. Also called hack and squirt.



Pulse disturbance – a one-time disturbance followed by little disturbance that allows an ecosystem to recover the conditions that were present prior to disturbance. Examples for an Eastern hardwood forest are a microburst resulting in tree fall or one season of gypsy moth defoliation.

Urbanized deer – deer that live in urban or suburban environments that feed in gardens and yards, tolerate the sight of people and sounds of cars, and do not leave.

Variable plot sampling – a method of forest sampling in which sample trees are selected with a probability proportional to their basal areas (i.e. large trees with large basal areas have higher probabilities of selection than smaller trees).

1.0 INTRODUCTION

The Bay Ridge Civic Association (BRCA), which owns Bay Ridge Forest (the Forest), desires a benchmark inventory of the various plants, wildlife, and soils that exist in the two main areas of the Forest in order to inform future management and stewardship. The Forest is preserved through conservation easements held by the Bay Land Trust and Maryland Environmental Trust. BRCA has a State Forest Stewardship Plan and a Forest Management Committee to guide management of their Forest, but wants a baseline inventory of the natural resources before continuing to implement the plans.

Environmental Systems Analysis, Inc. was tasked with surveying the underlying tree, shrub, and ground layer plants of the Forest; quantitatively and qualitatively surveying and documenting the vegetative species for a plant inventory of the Forest; observing wildlife and signs of wildlife within the Forest; and surveying the soils type and conditions within the Forest. We used repeatable standard field methods of ecology to analyze trends through time.

2.0 GENERAL SITE CONDITIONS

Bay Ridge is a residential community near Annapolis in Anne Arundel County, Maryland. BRCA owns approximately 91 acres of forest within Bay Ridge, though this study focused on the two main areas of the Forest. West and East Lake Drive, Farragut Road, Lake Ogleton and Annapolis Cove subdivision bound Area 1, which is 37.1 acres. Area 2 is 40.4 acres and includes two forest patches separated by Herndon Road. Area 2 is bounded by Hull Avenue, Blackwalnut Creek, Farragut Road and the Annapolis Cove subdivision boundary. Our study area included paper roads and some tidal waters, but not lots at the corner of Herndon Road and Farragut Road. Area 3, which includes several small forested parcels, was not included in this study.

The sites are completely forested except for tidal wetlands dominated by common reed (*Phragmites austrailis*) and Herndon Pond. Topographically, gentle 5-10% slopes dominate the forest, though there are steep slopes along the border of the pond, tidal wetlands, and Blackwalnut Creek. The forest soils are mostly sandy loams.

BRCA installed four deer exclosures in the Forest at the start of this study. The exclosures are 20’ x 20’ and are made with 7.5’ tall fencing. The corners of the exclosures use 4” x 4” posts and the sides are stabilized with t-posts. The exclosures were installed to monitor the effect of deer

on understory vegetation and soil. They were placed close to deer trails, outside of the existing invasive species treatment areas, in upland forest outside of swales or wetlands, and more than 150 feet from roads, backyards, or Blackwalnut Creek.

3.0 METHODS

ESA conducted site visits in the Forest on April 13, May 11, June 6 and September 5, 2012. We followed Natural Resource Inventory and Forest Stand Delineation methodology documented in the *State Forest Conservation Technical Manual*, Third Edition, 1997, Maryland Department of Natural Resources.

3.1 Natural Resources Inventory

We created a base map in AutoCAD using Anne Arundel County topography, wetland, and tree boundary layers and property boundaries from Drum Loyka Associates. We then added soils from USDA Natural Resources Conservation Service Web Soil Survey and identified steep slopes (15-25% and 25% and greater).

3.2 Forest Stand Delineation

Our study protocol involved the delineation of all forest stands and their acreage within our study area (see Appendix D). The forest stands are delineated based on species composition, density, size, condition, and age of the stand. The dominant, co-dominant, and sub-canopy tree species for each stand are identified and tabulated to indicate their relative frequencies and average tree diameter class. The forest stands are further described in the Results section below, including the identification of the shrub and herbaceous species.

We determined Forest Data Station locations by ensuring coverage throughout the BRCA forest and among the different soil types that represent topographical and vegetative diversity. At each Forest Data Station location, we delineated a 37.2’ radius circle (0.1 acres plot) or used the boundaries of the deer exclosure. We installed an orange stake, flush with the ground, at the center of the circle, flagged the stake and labeled the flag. Additionally, using a Trimble Geo-xh GPS Unit with a Hurricane Antenna, we surveyed the center of the plot so that the plots can be

found by others in the future. The GPS data was rectified with Pathfinder for a minimum accuracy of 3 feet. The sample points are located on the enclosed map in Appendix D.

We identified and counted trees that fell within each Forest Data Station (i.e. either the 0.1 acre area or within the 0.01 acre deer exclosure). This data was used to estimate the number of trees per acre and to calculate basal area. Basal area is a measurement of the cross-section of a tree in square feet at 4.5 feet above the ground. Basal area of a forest stand is the sum of the basal areas of the individual trees and is reported per acre.

Additionally, we conducted variable point sampling at each Forest Data Station using a 10 factor wedge prism. Because the Bay Ridge Forest has large trees that are not close together, the variable point sampling picked up more canopy trees and may have more accurate estimates of species frequency of occurrence and volumes. Variable point sampling refers to a method in which sample trees are selected with a probability proportional to their basal areas (i.e. large trees with large basal areas have higher probabilities of selection than smaller trees). Using a 10 factor wedge prism for sampling, it can be shown that each tree selected within the variable plot represents 10 square feet of basal area per acre. At the center of each Forest Data Station, we used the prism to determine which trees fell within the sample area and then tallied and measured those trees.

Information collected within each Forest Data Station included:

- Percent canopy closure and tree species observed including relative dominance
- Percent and species of shrubs
- Percent and species of forest floor covered by herbaceous plants
- Percent of forest floor covered by downed woody debris,
- Percent of invasive cover in the ground cover layer, understory layer and canopy layer
- Soil texture and moisture

We reviewed historical aerial photos stored at the Anne Arundel County Map Room for forest age, composition, and disturbance.

3.2 Soils Assessment

At each Forest Data Station, we collected soil from the top six inches and recorded its texture and moisture level. Soil samples from each forest stand type mixed to achieve an average sample and the two resulting samples were sent to A&L Eastern Laboratories for chemical and textural analysis. A&L evaluated the soils for texture, organic matter, estimated nitrogen release, phosphorus, potassium, magnesium, calcium, pH, buffer pH, hydrogen, cation exchange capacity, and % base saturation.

3.3 Wildlife Assessment

During each field visit, ESA looked for den activity, hair, fur, scat, footprints, movement trails, calls, road kill and direct observation of wildlife. We visited the nontidal Herndon Pond several times for the purpose of an abbreviated 'herp' survey to identify egg masses and any observed amphibians. ESA paid special attention to evidence of deer browse. Deer have an overbite and clip vegetation at an angle, often leaving a tear-tab. Most all other small mammals in the rodent family (i.e. mole, vole, shrew, mouse, chipmunk, squirrel, rabbit and groundhog) clip vegetation with an even-toothed snap creating a straight -line cut. It is the angle cut that is evidence of deer browse. ESA also noted which species appear to be most palatable/ preferred by deer (i.e. hardwood seedlings).

ESA installed four motion-sensor cameras in the Forest at logical movement corridors. The cameras were installed on May 11 and collected on June 6. The month of May is a busy time for wildlife because of establishment of territory, mating, breeding, brood rearing, and extended feeding and foraging. This increases the likelihood of being observed through motion-detection photography. Cameras recorded images of wildlife and people that triggered the motion-sensor. Appendix A includes a few representative photos from these cameras.

We did not conduct a formal bird study, nor did we use traps to identify wildlife present. All wildlife and bird observations were incidental.

4.0 RESULTS

4.1 Forest Vegetation

Based on interpretation of historical aerial photos, this site has been forested since at least the 1940s. An October 17, 1952 aerial photo showed that the entire BRCA Forest had a closed canopy and was forested in hardwoods. Herndon Pond did not exist yet. By January 17, 1962, a dirt road, Walnut Drive, had been built through the forest of Area 2, from Crisland Drive (or nearby) to Herndon Avenue, near what is now Herndon Pond. The remains of this road are still apparent both on the topography map and in the Forest. The Forest grew taller from 1952 to 1962. Also apparent in the 1962 photo was a gap in the canopy in Area 1 near Forest Data Station 7, which still remains today. By 1970, Herndon Pond had formed. By 1977, Walnut Drive, which crossed the forest of Area 2, was abandoned and the gap in Area 1 near Forest Data Station 7 was more apparent (see Appendix A for 1952 and 1984 historical photos).

ESA divided the Forest into two forest stands, Tuliptree Forest and Chestnut Oak Forest. The division was based on the dominant tree species and other common characteristics of the Forest Data Stations. The NRI/FSD map shows the general location of these forest communities with the Chestnut Oak Forest located along the banks of Blackwalnut Creek and the Tuliptree Forest encompassing the majority of the forest. Data from each forest data station can be found in Appendix B.

Basal area equates to stocking, which is a general description of the density of the forest stand as compared to the desirable density for best growth and management. Stands may be described as under stocked – a stand of trees so widely spaced that, even with full growth potential realized, crown closure will not occur; well stocked –a forest stand contains trees spaced widely enough to prevent competition, yet closely enough to utilize the entire site; and overstocked – a stand of trees so closely spaced that they are competing for resources, resulting in less than full growth potential for individual trees. Basal area per acre values are scored as non-stocked (0 to 9), poorly stocked (10 to 59), moderately stocked (60 to 99), fully stocked (100 to 129), and overstocked (130 to 160) (*Forestry Handbook, K.F. Wenger, 1984, pg. 318-321).* There is a correlation between stand density and canopy closure, typically recognized as under stocked (under 40% crown closure), well stocked (40-70% crown closure), and overstocked (over 70% crown closure) (*Stoddard 1968*).

4.1.1 Tuliptree Forest

The canopy of the Tuliptree Forest is strongly dominated by tuliptree (*Liriodendron tulipifera*), also known as tulip poplar or yellow poplar. The shrub layer is strongly dominated by spicebush (*Lindera benzoin*). Other species commonly found throughout this stand include sweetgum (*Liquidambar styraciflua*), American holly (*Ilex* opaca), jack-in-the-pulpit (*Arisaema triphyllum*), enchanter's nightshade (*Circaea lutetiana*), grape (*Vitis* sp.), common greenbrier (*Smilax rotundifolia*), Virginia creeper (*Parthenocissus quinquefolia),* Asiatic bittersweet (*Celastrus orbiculata),* English ivy (*Hedera helix*), and poison ivy (*Toxicodendron radicans)*. We also noted a Virginia bluebells, a native wildflower, in this forest.

This forest type is part of the Tulip Tree Forest Alliance, which is described in the *Classification of Vegetation Communities of Maryland: First Iteration*, as a pure, even-aged stand that usually grew from old field, clearcut or natural disturbance conditions. Vines are abundant in this forest type and typically include grape, greenbrier, and Virginia creeper. This stand classifies in the International Vegetation Classification of ecological communities as CEGL004418 – Sweetgum-Tuliptree/Northern Spicebush/Jack-in-the-pulpit Forest. This ecological community also has the common name Upper Southeast Small Stream Sweetgum - Tuliptree Forest. The following description given for this natural community is helpful in identifying the predominance of the Bay Ridge Forest stand:

These low-elevation forests develop along relatively acidic soils on small streams in the Coastal Plain of Maryland and Virginia, extending west across the Virginia and North Carolina Piedmont to the Cumberland Plateau and Ridge and Valley. The topographic features of floodplains can heavily influence the makeup of individual examples of this association. The canopy, subcanopy, shrub, and herbaceous layers often are well-developed. Dominant canopy species always include Liquidambar styraciflua *[sweetgum] and* Liriodendron tulipifera *[tuliptree], while* Acer barbatum *[southern sugar maple, not native to Maryland] (in the eastern part of the range),* Platanus occidentalis *[sycamore], and* Acer rubrum var. rubrum *[red maple] may also make up significant amounts of the canopy. This community type exists as a continuum between two subtypes, i.e., the tuliptree subtype and the sweetgum subtype. In some examples, only one or the other dominates the canopy, but in many examples, both are equally dominant. Common species in the canopy and understory include I*lex opaca var. opaca *[American holly],* Aesculus sylvatica *[painted buckeye],* Betula nigra *[river birch],* Carpinus caroliniana ssp. caroliniana

[ironwood] , Cornus florida *[flowering dogwood],* Carya cordiformis *[bitternut hickory],* Fagus grandifolia *[American beech],* Fraxinus americana *[white ash],* Fraxinus pennsylvanica *[green ash],* Halesia tetraptera var. tetraptera *[mountain silverbell, not native to Maryland],* Juglans nigra *[black walnut],* Juniperus virginiana var. virginiana *[Eastern red cedar],* Morus rubra var. rubra *[red mulberry],* Nyssa sylvatica *[black gum],* Ostrya virginiana var. virginiana *[hophornbeam],* Oxydendrum arboretum *[sourwood, endangered in Maryland],* Pinus echinata *[shortleaf pine],* Prunus serotina var. serotina *[black cherry],* Quercus alba *[white oak],* Quercus rubra var. rubra *[northern red oak],* Ulmus rubra *[slippery elm],* Ulmus Americana *[American elm], and* Ulmus alata *[winged elm].* Euonymus americanus *[American strawberrybush],* Asimina triloba *[pawpaw],* Lindera benzoin var. benzoin *[spicebush], and* Corylus americana *[hazelnut] are common in the shrub layer. The herbaceous layer is species-rich and often has good sedge development. The exotics* Microstegium vimineum*,* Glechoma hederacea *[gill-over-the-ground],* Rosa multiflora *[mulitflora rose],* Ligustrum sinense *[Chinese privet], and* Lonicera japonica *[Japanese honeysuckle] are common in this community (NatureServe Explorer 2012).*

There are several items of interest in this above description. The Bay Ridge Forest is clearly the tuliptree subtype, with 13 of the 14 plots within this stand clearly dominated by tulip tree and the last plot (plot 5) dominated by sweetgum. Of note in the above description is that American strawberry bush and pawpaw are typically common in this forest type. Though, ESA did document both of those plants on site, neither is particularly common. American strawberry bush (*Euonymus americanus*) is a favored plant of deer, whereas pawpaw (*Asimina triloba*) is known to be deer-resistant. This species is a good choice to plant as an understory tree/shrub. Also of note is that the typical forest of this type has a species-rich herbaceous layer, good sedge development and exotics are common.

Based on the 1/10th-acre plot method of collecting data, this forest stand has approximately 139 trees per acre and a basal area of 156 sf per acre. Based on the variable point sampling method, this stand has approximately 76 trees per acre and a basal area of 90.8 sf per acre. Because this stand has large canopy trees that are well spaced, ESA believes the variable point sampling method provides a more accurate description of this forest stand because there were few canopy trees that fell into any given 1/10th-acre plot. Whereas, with variable point sampling, large trees that are further away are captured in the data. The average diameter of tulip trees in this stand is between 18.7” and 21.1” and they compose 30.8% of all trees in this

forest stand. Canopy closure was approximately 67%; understory/shrub cover (defined as 3-20") was high at 50%; and groundcover (below 3') was also high at 25.6%. Woody debris was average for a mature hardwood forest at 4.5%. Invasive cover was high with approximately 15% of the ground covered in non-native invasive plants and 4% of the understory covered in non-native invasive plants. During our late spring and early summer field visits, the soil was usually covered by a light layer of leaves in this forest stand, though in the wetter areas, exposed soil occurred. In an area where there is a gap in canopy cover, groundcover was very thick and the soil or leaf litter was not exposed.

4.1.2 Chestnut Oak Forest

Chestnut Oak Forest stands are typical of depauperate, well drained soils and are common along the Western Chesapeake Bay shoreline. Forest Data Stations 15, 16 and 17 are part of this forest type and chestnut oak dominates the canopy, though southern red oak, northern red oak, sweetgum and tuliptree are also present. American holly is very common in the understory. Other understory plants include ironwood, flowering dogwood, and blackgum. The groundcover includes lowbush blueberry, tick trefoils, common greenbriar, Virginia creeper, Christmas fern, avens, lady fern, partridgeberry, oak seedlings, and invasive species.

This forest is part of the Chestnut Oak- White Oak, Southern Red Oak, Northern Red Oak, Black Oak Forest Alliance which is described in the *Classification of Vegetation Communities of Maryland: First Iteration*. Though oaks dominate now, chestnut (C*astenea dentata)* was found within this forest stand and was probably a dominate player in this forest type before the chestnut blight wiped out most of the reproducing chestnuts in the U.S.

Because of the large number of American holly trees, this forest stand has a distorted estimated number of trees per acre and basal area based on the $1/10^{th}$-acre plot method: approximately 2,900 trees per acre and a basal area of 1,695 sf per acre. The large majority of the American hollies were 2-4 inches in diameter. Based on the variable point sampling method, this stand has approximately 235 trees per acre and a basal area of 106 sf per acre. This stand is considered fully stocked at just over 100 sf per acre. The average chestnut oak is between 12.5" and 18" in diameter. They represent about 20% of the trees in this forest stand. Canopy closure was approximately 63%; understory/shrub cover (defined as 3-20") was high at 40%; and groundcover (below 3') was average at 8.3%. Woody debris was average for a mature

hardwood forest at 4.7%. Invasive cover was moderate with approximately 4.7% of the ground covered in non-native invasive plants and 10% of the understory covered in non-native invasive plants. The soils were dry and covered in leaf litter.

4.1.3 Deer Exclosure Vegetation Site Descriptions

Often the deer exclosures were small enough to not include trees. Plot 3 did not have any canopy or subcanopy trees, though it did have several seedlings including American holly, spicebush, hickory, red maple and box elder. Plot 7 had one red maple that was 5-7 inches in diameter. It also had some seedlings including black cherry and tuliptree. Plot 8 had one white oak and one sweetgum, both 2-4 inches in diameter. Seedlings in that plot included sweetgum, American holly, hickory, and chestnut oak. Plot 14 had four trees: one American holly and two flowering dogwoods that were 2-4 inches in diameter and one tuliptree that was 20-22 inches in diameter. The seedlings present in this plot included spicebush and American holly.

All of the deer exclosures had invasive species present. The percent of invasives in the groundcover layer (0-3' tall) ranged from 5-15. The understory (3-20' tall) had 0-5% invasive cover. All of the deer exclosures are within the tuliptree forest stand. However, anecdotally, we did not notice a notable difference in deer browse, trails, droppings or bedding areas between the two forest stands. Comparison of baseline vegetation to vegetation present five or more years from now will be useful in determining how deer are impacting the Bay Ridge Forest. We recommend leaving the invasive species present within the deer exclosure in order to better understand the role deer have in spreading invasive species.

4.1.4 Invasive Species Summary

Bay Ridge is a stately, mature and established community, with woodlands surrounding and enveloping many homes. Shade tolerant landscape plants such as English ivy, periwinkle, vinca and pachysandra are a landscape mainstay in many of the residential properties. Inadvertently however, these plants have escaped from the landscape and invaded the natural area woodlands, along with other "disturbance species." The spread of these alien invasive plants is partially due to improper landscape dumping (vegetative clippings) and seed dispersal via

wildlife, primarily deer and birds. Deer, and other herbivores, can carry seeds on their fur or can disperse seeds through ingestion.

From our observation the vine species of most concern for Bay Ridge include English ivy (*Hedera helix*), Creeping Euonymus (*Euonymus fortunei*), Periwinkle (*Vinca minor*), Oriental Bittersweet (*Celastris orbiculatus*), Wisteria (*Wisteria sinensis* and *W. floribunda*) and, to a lesser extent, Mile-a-Minute (*Polygonum perfoliatum*). The grass and forb species of highest concern are Japanese stiltgrass (*Microstegium vimineum*), Common Reed (*Phragmites australis*) and, to a lesser extent, Garlic Mustard (*Alliaria petiolata*). A highly invasive ground cover plant known as Lesser Celandine (*Ranunculus ficaria*) was first observed this year along Hull Avenue and successfully managed by the Forest Management Committee. The shrub and tree species of most concern are Privet (*Ligustrum spp*.), Bush Honeysuckle (*Lonicera spp.),* Wineberry (*Rubus phoenicolasius*), Paper Mulberry (*Broussonetia papyrifera*), and Tree-of-Heaven (*Ailanthus altissima*).

4.2 Wildlife

Wildlife does not recognize political boundaries, nor stay within fixed locations. When interpreting aerial photography it is obvious the Bay Ridge natural area is a woodland tract that supports an abundance of appropriate, endemic wildlife species. Because of its relatively large size and degree of maturity, the tract emulates elements of forest interior, which supports forest interior dwelling species (FIDS). From a recruitment perspective, the tract is part of a larger regionalized area of woodland corridors, wedges, and woodlots that sustain and support wildlife.

We observed either directly or anecdotally (i.e. scat, footprint, or den) deer, grey (and black) squirrel, red fox, field mouse, opossum, raccoon, rabbit, ground hog, box turtle, ground bee, bumblebee, ladybug, and bullfrog in BRCA forest. We also heard or saw the following birds: Downy Woodpecker, Fish Crow, Common Crow, Common Grackle, Great Blue Heron, Red-wing Blackbird, Osprey, Yellow-bellied Sapsucker, Canada Goose, American Robin, Turkey Vulture, and Bald Eagle. A host of reptiles, amphibians, butterflies, moths, insects, spiders, birds and fisheries occur within the forest interior, forest edge, grasslands, and littoral fringe nontidal and tidal wetlands and waters. We expect mole, vole, shrew, muskrat, chipmunk, and river otter to

be present in or on the edges of BRCA Forest. Skunk may be present, though we did not observe it.

Throughout this forest we saw deer, deer beds, deer droppings and vegetation clipped by deer. Clipped greenbrier is particularly noticeable. The extent of damage by deer to the forest is most evident in the high cover by invasive species and what is missing. Seedlings were not common and the shrub and groundcover layers were dominated by unpalatable species, like spicebush and jack-in-the-pulpit. With our multiple visits to analyze forest structure, it became evident to us that deer may be in excess of carrying capacity. Why do we say that? (1) Deer browse is quite evident as a "browse line" is apparent at many locations within the forest interior and edge. (2) Forest regeneration is somewhat limited as seedlings and saplings were lacking at many locations. The young growth of woody plants is a preferred food for deer, and is being targeted within the Bay Ridge woodlands. (3) We observed "urbanized" deer with regularity and pushed them throughout the forest in areas utilized for forage, loafing, shelter, etc. Deer trails, deer scat, young of year, and pregnant does were observed with regularity, including within residential landscapes and lawn areas. (4) The forest floor forb/herb layer is lacking as the overall count of species was depressed in comparison to other local/regional natural areas. (5) The success of alien invasive plants is in part due to the disturbance by deer, as most non-native invasives are not palatable/preferred as forage and are allowed to succeed without interference. (6) The existing palatable shrubs, vines and forbs are coppiced, where twigs re-sprout as they are being fed upon, generating multiple suckers of adventitious and epicormic sprouting.

4.3 Soils

The site is part of the Coastal Plain province and is underlain by sandstone, a sedimentary rock. The rock is part of the Magothy Formation, which was formed during the Cretaceous Period when this site was underwater and deposition of sands, silty clays and gravels occurred (Maryland Geological Survey 1968*)*. This rock has glauconite, which is a mineral indicative of marine depositional environments with slow rates of accumulation.

The mapped soils on-site are mostly Annapolis sandy loam, Annapolis fine sandy loam, Collington and Annapolis soils, and Donlonton-Urban land complex. The forest soils are all well

drained and do not flood or pond. The water table is often more than 80 inches under the surface. The tidal wetland soils are mapped as Widewater and Issue soils and Colemantown silt loam. These soils are poorly drained and contain finer silts.

An exhaustive state-wide forestry study was performed by Johns Hopkins University entitled *The Natural Forest of Maryland* (Brush, Lenk & Smith, May 1977). This study identified two major forest types in and around the greater Annapolis area with elements of both forest types being expressed at Bay Ridge, and in large part due to soil types. Much of the soils along the Western Shore of the Chesapeake Bay are loamy sands that are quick to dry (high porosity) and do not hold moisture or nutrients very well. Because they occur on ridge tops and slopes, the top soil is usually rather thin. These conditions favor the biological indicator species that is predisposed to performing well in these conditions, which is chestnut oak.

Where topsoil does not wash downhill easily (i.e. flats, within coves and on gentle slopes), soils often develop into more sandy loam rather than loamy sand. In these conditions soil fertility improves. Topsoil becomes more developed and deeper, containing higher organic content with increased nutrient and moisture holding capabilities, and thus allowing for tuliptree to become an expressed dominant overstory species.

The soil samples sent to A&L Labs confirmed that both stands have sandy loam soils (see Appendix B). The chestnut oak stand soils were more acidic and generally had lower nutrients than the tuliptree stand soils. The pH of the chestnut oak stand soil was 4.6, whereas the tuliptree stand had a pH of 5.4. The organic matter in the top 6” for both stands was about 2.5%. Compared to ideal soils for lawns and gardens, phosphorus and calcium were low for both forest stands. Potassium was moderate for the tuliptree forest stand and low for the chestnut oak forest stand. Magnesium was optimum for both forest stands.

5.0 DISCUSSION AND MANAGEMENT RECOMMENDATIONS

5.1 Future of Forest Composition and Structure

The current forests on-site have structure that is not entirely healthy. There are enough canopy trees to promote canopy closure at 63% or greater, a thick shrub layer, and a groundcover

layer. The subcanopy layer is sparse in some areas and the groundcover layer is thicker than a healthy forest. The two most influential sources of on-going stress and disturbance to the native BRCA Forest are deer and invasive non-native plants. These stressors are impacting habitat for other wildlife and birds, as well as impacting the forest's ability to regenerate.

The canopy trees are mature and possibly stressed by vine intrusion, which weighs on the tree and more importantly, occupies space in the canopy where tree leaves could grow. Killing the non-native vines climbing the trees will help the health of the canopy trees. Thinning the forest for wildlife habitat and forest health purposes may be appropriate in the future once the invasive vine populations are significantly lowered and the forest basal area is overstocked. Until the invasive species are better controlled and tree seedlings are more common, light gaps caused by thinning will only promote invasive plant growth.

The percent cover of plants below 3' tall is very high in the tuliptree stand due to invasive vines and other non-native plants. Removal of these invasive plants will help restore the groundcover layer to a more natural composition of native sedges, forbs, seedlings and vines and a lower percent groundcover (below 10 percent).

There were tree species represented in most size classes, particularly in the chestnut oaks within the chestnut oak stand. However, seedlings and saplings of canopy tree species were not common in either stand, which means the forest has a limited capacity to regenerate. Some areas of the Tuliptree forest are missing the subcanopy layer, with a gap between the top of the spicebush (about 10 feet) and the canopy (50 feet and taller). The lack of seedlings, saplings and subcanopy layer may be due to overabundance of deer, which are known to eat seedlings and nuts, including acorns and hickory nuts.

The Tuliptree stand had on average about 12.5 canopy species seedlings (tuliptree, oaks, black cherry, red maple, hickories and sweetgum) per acre. The chestnut oak stand had on average 10 canopy species seedlings (oaks and sweetgum) per acre. A typical Eastern hardwood forest has about 100-400 seedlings per acre (Horsley 2003). In the 2-4 inch diameter class trees, which includes saplings, there were again about 10 canopy species trees per acre for the tuliptree stand and 16 canopy species trees per acre for the chestnut oak stand. We suspect that the cause of this lack of seedlings and saplings is due to deer browse. Planting canopy tree species

such as oaks, hickories, tuliptree, sweetgum and red maple that are taller than the deer can browse (approximately five feet) in light gaps may promote healthier forest structure and allow the canopy to be replaced when taller trees die or fall. Also, when choosing a shrub/understory species to plant within the forest, pawpaw (*Asimina triloba*) may be a good choice because it is deer-resistant and indigenous to the tuliptree stand.

We do not recommend implementing any of the fertilization recommendations from the soil lab, as this site is for trees, not lawn or vegetables. A lack of soil nutrients and acidic soil in the chestnut oak stand may be helping to suppress invasive species.

5.2 Impact of Deer on Forests

It has been shown that selective browsing by deer result in reduced plant diversity and altered species composition dominated by unpalatable species. Other studies on the impact of deer on forest vegetation have shown that increasing deer densities lead to lower densities of woody plants and lower seedling height; and that high deer densities have increasing impact over time (Horsley 2003). In one nature preserve where hunting was not allowed and the deer population is over 100 deer per square mile, "the forest resembles a park with canopy trees and a carpet of Japanese stiltgrass spread and sustained by deer disturbance of the soil (Natural Lands Trust 2009 Deer Management Options)."

The National Park Service performed a five-year deer study in Fairfax County, Virginia (Rossel et. al. 2004). The study was conducted to determine whether excessive deer browse was reducing growth and survival rates of tree seedlings and saplings, which could cause irreversible shifts for a stable-state forest community by altering species composition. The Manassas National Battlefield had an estimated 67 deer/km^2 (174 deer/mi^2) and with all forest exhibiting a prominent browse line. The natural resources management staff built ten 2- meter by 10-meter exclosures, along with ten control plots. They used the *Browse Impact Protocol* to collect ground and vertical plant cover information through the five-year period. The study documented that annual seedling survival rates were consistently significantly lower in the control than in the exclosures. It was determined that deer were having a significant impact on the vegetation structure and composition of woody seedlings. Herbivory by deer severely impacted forb cover by suppressing forb densities to levels much lower than would be expected

in the absence of deer. By the fifth and final year of the study, forb cover in the exclosures was at least 30-percent greater than in the controls.

5.2.1 Potential Studies on the Impact of Deer on Bay Ridge Forest

The Forest Management Committee installed deer exclosures throughout the Forest to better understand the forest's potential when deer are denied access. The forest within the exclosure can guide deer management outside. Over time the exclosures may indicate what species may rebound from the lack of feeding pressure or how resilient the forest may be as feeding pressure is reduced. It is expected that an exclosure would allow for seed rain to develop seedlings. The enclosures may express various wildflowers that naturally occur within the seed bank or are typical of the forest type but are suppressed elsewhere because they may be preferred by deer. It would also be expected that non-native species such as *Microstegium* would not be as evident as disturbance is eliminated. These test plots could reveal the differences of how deer assert themselves within the forest and whether they are affecting natural regeneration, per Rawinski 2008 and others.

Repeating this forest delineation study allows you to compare both native and non-native species presence/absence, percent cover of plants below 3', and percent cover of invasives within and outside the deer exclosures.

We recommend you fully utilize your deer exclosures by conducting a formal study, starting this year. As a baseline, a natural resources professional should record the height, species and number of plants below 5 feet within each exclosure and within four control plots (also 400 square feet). Also, the researcher should record species and number of taller plants within each exclosure. In five years or more, repeat the study. Alternatively, natural resources professionals could implement the National Park Service's Browse Impact Protocol to collect ground and vertical plant cover information. The protocol is based on the use of point-intercept methodologies for ground cover and vegetation profile board for vertical plant cover (bottom, middle, top). Information is collected within a deer exclosure and nearby control plot, ultimately evaluating the difference between the two.

Hypotheses to test:

1. There will be higher densities of native plants in the exclosures.
2. Fewer invasive non-native plants will be present in the exclosures.
3. More seedlings will be present in the exclosures.
4. Seedlings will be taller in the exclosures.
5. Deer-preferred species will be more common within the exclosures.

Alternative and recognized studies related to the impact of deer on vegetation include a protocol used by the Fairfax County Park Authority (deCalesta et. al.). These protocols include the ability to document deer density through fecal pellet counts along random transect lines. A one-time baseline and/or multi-year census using the pellet count methodology could be performed at Bay Ridge. The gist of the protocol is to count pellets for each plot along transects, with a calculation being made based on the number of pellet groups, number of days, and ratio of 1,000 (mil acres) to one (plot). The average is taken across all plots to get a number of deer per acre, then multiplied by 640 (acres) to get an estimated number of deer per square-mile. Using pellet count plots with a four-foot radius, browse intensity is identified/documented on each plant within plot by using a numeric value starting at 1 for *"not browsed"* to 5 for *"severely browsed."* Deer browse their favorite species first, and hit them harder than less preferred species. If local deer populations should exceed carrying capacity, the first species lost will be the most preferred/palatable, which is documented through the browse impact observation method.

5.2.2 Deer Impact Index

The Natural Lands Trust wrote a deer management guide that details the impact of deer on forests and how deer exclosures can be used. In this guide, they include the US Forest Service and Penn State University's five-level deer impact index to qualitatively assess the level of deer influence on forest health:

Deer Impact Index 1

Very low: No deer browse. Occurs only within a well-maintained deer exclosure.

Deer Impact Index 2

Low: Species composition and height of regeneration is determined mainly by available light, nutrients and seed source. There is a well-developed shrub layer and native wildflowers are abundant and grow to their full size.

Deer Impact Index 3

Moderate: Evidence of browsing is common with a greater reduction in height and abundance of the most-preferred species than of the least-preferred species.

Deer Impact Index 4

High: Preferred species are sparse or absent and all plants are nearly the same height as a result of browsing. Vegetation in the shrub layer is sparse except for the least-preferred species (e.g., spicebush, American beech, exotic invasive shrubs).

Deer Impact Index 5

Very high: A pronounced browse line is evident with virtually no vegetation below the browse line except for two rhizomatous fern species, hay-scented fern and New York fern or exotic invasive herbaceous species such as Japanese stiltgrass and garlic mustard.

Based on the descriptions above, we characterize the Forest as having a Deer Impact Index of 3 to 4. The overpopulation of deer in Bay Ridge appears to be affecting the forest composition. Preferred species are sparse and the shrub layers are dominated by least-preferred species. Tree and shrub seedlings are not common, wildflower diversity is moderately low and invasive species are abundant.

5.3 Deer Management

USDA Wildlife Services conducted a deer survey of Bay Ridge on January 19, 2012 (USDA 2012). They spotted 42 deer, though six deer may have been observed twice, so there are at least 36 deer in Bay Ridge Community. Based on these findings and the survey area, the population density of deer in Bay Ridge is at least 60 deer per square mile. It is expected that this population will continue to rise unless controlled. Though Maryland Department of Natural Resources does not have a set deer population density goal, they generally work towards a long-term goal of 20 deer per square mile and Phil Norman, deer manager for Howard County, has a management goal of 15 per square mile (pers. comm. 2011).

Based on direct observation while we were in the field, the deer population at Bay Ridge has grown beyond the ecological carrying capacity, or the ability of the plants to thrive given the number of deer. This elevated deer population places immense pressure on native plant communities by stunting the natural regeneration of the landscape, not allowing new generation of trees to germinate and mature and eliminating shrubs and non-woody plants. Evidence of over-browsing by deer was seen in most all of the Bay Ridge natural areas. The result is a landscape with little native deer-preferred vegetation below five-feet. Both the plant communities and the animals that depend on them are affected by these ongoing impacts. Even eight deer per square mile can be a problem for vegetation (i.e. shrub, understory, invasives and landscape feeding). Four deer per square mile may be best for the purpose of sustaining healthy woodlands.

Deer do not solely rely on natural areas for food and habitat. Deer damage was also observed on private residential land through the loss of ornamental plantings. One of the most dangerous aspects of an elevated deer population is the possibility for collisions with cars and the injuries that can result as well as the increased indices of ticks and tick-borne disease.

A management goal for the Bay Ridge natural areas is to protect the natural resources entrusted to BRCA care. Deer are highly successful animals that can increase their herd size by up to 40-percent per year. In order to check rising numbers and reduce long term impacts to natural areas the BRCA should consider a deer management plan, which employs periodic culling operations or other population control.

Deer management options for controlling deer populations include relocation, repellants, surgery, fixed wire fences, contraceptives, sharpshooting and regulated hunting (MD DNR 2009 and MD Co-op Extension). Vegetation repellants work for 7-weeks maximum and therefore, treatment must be repeated often and their effectiveness decreases as the deer population rises. Sharpshooting involves baiting deer to a specific shooting location that enables shooters to kill only females. Hiring sharpshooters once provides 5-7 years of reduced deer populations and costs approximately $400 per deer. Contraceptives are approximately $15 per prescription (one animal unit), but the deer must be tagged and handled, which increases the price dramatically. Contraceptives last for one year only. A field-surgery ovarectomy costs a minimum of $1,200 per deer.

ESA has continued to track multiple municipal level deer management programs, all of which appear to emphasize professionally managed hunts utilizing either archers and or firearms.

5.4 Invasive Species Management

Per our observations and discussions with the BRCA Forest Management Committee, they are quite aware and proactive regarding their understanding of the long term ecological threat that invasive, non-native plants pose to forest integrity. The committee has engaged in invasive plant suppression activities especially along the forest edge, where many invasive plants types are most pronounced and successful (the edge effect).

Non-native species rank differently as some are highly invasive and have the potential for wholesale displacement of natural communities (i.e. kudzu) and others are just incidental in nature. It is the highly invasive species on which it is appropriate to concentrate efforts regarding suppression (see the Maryland Invasive Species Council website for a list of the highest invasive terrestrial plants in Maryland). Species on this list that are present in the Forest include tree of heaven, garlic mustard, Oriental bittersweet, English ivy, Japanese honeysuckle, bush honeysuckle, Japanese stiltgrass, eulalia/Miscanthus, Phragmites, mile-a-minute, lesser celandine, and multiflora rose.

It is our professional opinion, based on exposure to several Federal and County projects, that invasive plant management along disturbance edge corridors is labor intensive and requires multi-year efforts including eventual backfill seeding and/or reforestation planting to fill the void. We have observed numerous “edge” projects that have ultimately failed due to lack of the diligence of maintenance. As invasives readily recolonize the disturbance areas, monies and labor efforts have gone for naught.

For land managers on a budget with limited funding allocated for invasives, a newer philosophy is emerging regarding management options. The concept is to actively manage the best, highest quality natural areas (usually forest interior) first and foremost. Relatively mature forest interior is more resistant to “pulse disturbance activities” that promote invasives. As

invasives are observed, selective spot treatment is implemented to eradicate the immediate threat, while otherwise maintaining a light management footprint.

We recommend shifting your invasive management priorities from treating the forest edge to following the Natural Land Trust's management approach to invasive plants:

> *The focus of initial restoration efforts should be to halt the degradation of the canopy layer in the healthiest areas, moving then to the moderately invaded areas, and so on to the most degraded areas. Those areas that are severely invaded should, for now, be left for "dead." Since they essentially cannot degrade any further, their restoration (which will usually require significant resources, including heavy equipment and years of high maintenance) is best left until the healthier, less affected sites are stabilized. This approach is also healthier, psychologically, for the people involved in restoration. Spending the initial phase of a project stabilizing the majority of a site is more rewarding than struggling through a small, highly degraded section…. [However], all invasive vines should be treated as soon as possible* (Natural Lands Trust 2009).

The healthiest BRCA Forest area is the chestnut oak stand and the interior of Area 2, which currently has fewer invasive plants. There was 4.7% of the ground covered in non-native invasive plants in the chestnut oak stand compared to 15% in the tuliptree stand. The reasons for this discrepancy are unknown, but it may be because the chestnut oak stand is further from the road edge and/or because of fewer available nutrients and more acidic soils.

Notwithstanding this general guidance, spot treatments of highly invasive plants outside of the interior of Area 2 and the chestnut oak stand are advisable. In particular, we believe it is important to monitor and eradicate Lesser celandine to prevent its establishment. Other invasive species worth spot treating are tree-of-heaven and paper mulberry. Both of these species are within Area 1 and can be killed by girdling or frilling. We recommend re-planting the area with native tree and shrub species after killing these trees. Planted trees and shrubs may need deer protection if the newly planted material is coppiced or injured through rubbing. Planting stock higher than the deer-browse line will help protect the terminal bud.

Much of the invasive species treatment and replanting can be done over the course of years by volunteers. However, the use of professional landscapers to remove the invasives may be needed if you decide to tackle all of the vines in the canopy at once or if volunteer efforts are not making significant progress at suppressing invasive plants.

Because deer have been proven to spread plants including Japanese stilt grass and prefer to eat native plants (Biohabitats ISM 2011, Williams and Ward 2006), controlling the deer population will help to control the invasive species.

To curb new infestations of non-native plants, remind neighbors not to dump yard waste in the BRCA Forest. Similarly, limit users to those trails already established rather than allowing residents to create new trails.

5.5 Wildlife

This forest is home to many common suburban wildlife species. Herndon Pond is a main source of fresh water in the BRCA Forest and is also the main location for frog and salamander breeding. We recommend assessing the riser pipe of the pond for structural soundness and consider digging the pond deeper in the non-breeding season to ensure perennial water is present in times of drought.

One unique aspect of the BRCA Forest parcels are that combined, they are large enough to contain some interior forest (defined as more than 300 feet from a forest edge). Interior forest contains the highest quality breeding habitat for forest interior dwelling bird species (FIDS). This group of birds includes songbirds---tanagers, warblers, vireos, as well as woodpeckers, hawks, and owls. Some of these bird populations are declining in part due to habitat (interior forest) loss.

The Critical Area Commission for the Chesapeake Bay and Coastal Bays defines FIDS habitat as:

> A. Forests at least 50 acres in size with 10 or more acres of "forest interior" habitat (i.e., forest greater than 300 feet from the nearest forest edge). The majority of the forest tract

should be dominated by pole-sized or larger trees (5 inches or more in diameter at breast height), or have a closed canopy; or

B. Riparian forests at least 50 acres in size with an average total width of at least 300 feet. The stream within the riparian forest should be perennial, based on field surveys or as indicated on the most recent 7.5 minute USGS topographic maps. The majority of the forest tract should be dominated by pole-sized or larger trees, or have a closed canopy. Two forests tracts may be considered unconnected or disjunct if they are separated by nonforested habitat which results in a permanent 30-50-foot break in the forest canopy (e.g., road, cleared right-of-way).

Dr. Donald Messersmith conducted a bird study in 1995 in the Forest. Though invasive plant species have spread in the past 17 years, the size of the forest and composition of the canopy has not changed. Therefore, it is expected that most of the species Dr. Messersmith identified still use this woodlot. His study identified eight FIDS: Yellow-throated Vireo, Louisiana Waterthrush, Prothonotary Warbler, Worm-eating Warbler, Ovenbird, Acadian Flycatcher, Red-eyed Vireo, and Wood Thrush.

Managing the bird habitat of the interior forest, which can include forest along Blackwalnut Creek, should be a priority. The main management actions required is to remove invasive species and allow dead snags to remain standing.

We recommend keeping pets on leashes and encourage Bay Ridge residents to keep cats indoors to prevent small mammal and bird mortality. We did not see many cats outdoors near or in the Forest, so cats may not be much of a problem. However, they are not part of the native ecosystems, are known predators of wildlife and birds, and can impact wildlife and bird populations (Balough et.al 2011).

5.6 Other Natural Area Management Issues

There are other natural area management issues we recommend for the health of the natural area and safety of the people of Bay Ridge. Remind neighbors not to dump yard waste in the

BRCA Forest. Yard waste gives the impression that the forest is not valued and it can be a source of non-native invasive species.

Conduct an annual boundary survey for hazardous trees for the safety of users and nearby houses. Also during boundary survey, note encroachments into the community forest.

6.0 SUMMARY OF MANAGEMENT RECOMMENDATIONS WITH ROUGH COST ESTIMATE

1. Adopt a formal invasive species management plan or strategy that prioritizes the healthiest forest and the forest canopy. A formal invasive species management plan including goals, objectives, strategy and map would cost approximately $5000. Invasive species treatment and removal is an ongoing expense. Generally it costs $1800 per day for a two person landscaping crew to cut, spray with herbicide and remove invasive plants. Some of this work can be done by volunteers instead of a hired landscape crew. The top priorities for the next few years are as follows:
    a. Remove all highly invasive species from the Chestnut Oak Forest and interior of Area 2 - 3-4 days for the first year, 1 day for subsequent years
    b. Cut and treat vines on all canopy trees - 10 days
    c. Eliminate lesser celandine -1 day
    d. Control paper mulberry and tree-of-heaven - 2 days for first treatment, subsequent treatments may be necessary
    e. Plant canopy tree species and deer-resistant shrubs where invasive trees are removed and in light gaps (such as near FDS 7) - $70 per 1” caliper tree installed with buck guard, mulch, initial watering, and slow-release fertilizer, assuming a minimum of 20 trees being planted
2. Adopt a deer management plan or strategy to control the impact deer have on the forest structure and composition. Formal deer management plan including goals, objectives, strategy and map would cost approximately $5000. Cost to implement the plan will depend on the method.
3. Conduct a formal vegetation study of the deer exclosures. A study as described above would cost approximately $7000.

4. Assess the riser pipe of Herndon Pond for structural soundness and consider digging the pond deeper. To assess the pipe and conduct spot bathymetry would cost approximately $3500.
5. Remind neighbors not to dump yard waste in the BRCA Forest, keep dogs on leashes when in the Forest, and keep cats indoors. A natural resources professional writing a few paragraphs for your newsletter would cost approximately $400.
6. Limit trails to those already established rather than allow residents to create new trails. A natural resources professional writing a few paragraphs for your newsletter would cost approximately $400.
7. Conduct an annual boundary survey for hazardous trees and encroachments. A boundary study that includes marking trees to be removed and documenting encroachments would cost approximately $4000.
8. Allow dead snags to remain when not presenting a threat to persons or property. This management recommendation has no cost.

7.0 LITERATURE CITED

Balogh, A., T. Ryder and P. Marra. 2011. "Population demography of Gray Catbirds in the suburban matrix: sources, sinks and domestic cats," *J. Ornithol.* 152:3; DOI: 10.1007/s10336-011-0648-7.

Biohabitats ISM, 2011. *Fairfax County Non-Native Invasive Plant Assessment.* Fairfax County, Virginia Park Authority.

Brush, G.S., C. Lenk and J. Smith, 1980. The Natural Forests of Maryland: An Explanation of the Vegetation Map of Maryland. *Ecological Monographs* 50(1), pp. 79-92.

Critical Area Commission for the Chesapeake Bay and Atlantic Coastal Bays. 2000. *A Guide to the Conservation of Forest Interior Dwelling Birds in the Chesapeake Bay Critical Area*.

deCalesta, D., D. Jackson and T. Pierson. Pellet Group Count and Deer Browse Impact Survey. http://docsfiles.com/view.php?view=http://ecosystems.psu.edu/youth/sftrc/deer/pellet-count&keyword=david%20decalesta&count=

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(1): 98-118.

Maryland Cooperative Extension. Managing Deer Damage in Maryland, Bulletin 354. http://extension.umd.edu/publications/PDFs/EB354-C.pdf

Maryland Department of Natural Resources. 2009. Maryland White-tailed Deer Plan 2009-2018. http://www.dnr.state.md.us/wildlife/Hunt_Trap/pdfs/2009-2018MarylandWTDeerPlan.pdf

Maryland Geological Survey 1968. *Geologic Map of Maryland.*

Natural Lands Trust. 2009. *Controlling Invasive Plants*. http://www.tinicumconservancy.org/pdfs/Controlling%20Invasive%20Plants.pdf (Accessed September 6, 2012).

Natural Lands Trust. 2009. *Deer Management Options*. http://www.tinicumconservancy.org/pdfs/Deer%20Management.pdf. (Accessed September 6, 2012 and January 17, 2013).

NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. 2012. *Liquidambar styraciflua - Liriodendron tulipifera / Lindera benzoin / Arisaema triphyllum* Forest. http://www.natureserve.org/explorer/servlet/NatureServe?searchCommunityUid=ELEMENT_GLOBAL.2.684003, (Accessed July 23, 2012).

Rawinski, Thomas J. 2008. *Impacts of White-Tailed Deer Overabundance in Forest Ecosystems: An Overview,* Northeastern Area State and Private Forestry Forest Service, U.S. Department of Agriculture, Newtown Square, PA

Rossel, Reed and Bryan Gorsira. 2004. *Effects of Whitetail Deer on Three Forest Types in an Urban Park on the Piedmont Plateau.*

Rossell, C.R., Jr., B. Gorsira, and S. Patch. 2005. Effects of white-tailed deer on vegetation structure and woody seedling composition in three forest types on the Piedmont Plateau. Forest Ecology and Management 210:415-424.

Stoddard, C.H. 1968. *Essentials of Forestry Practice,* 2d ed. New York: Ronald Press Co. p.53.

Tremblay, Jean-Pierre, Jean Huot and Francois Potvin. 2007. Density-related effects of deer browsing on the regeneration dynamics of boreal forests*. Journal of Applied Ecology* 44, 552–562

USDA. 2012. Letter report to Board of Directors, Bay Ridge Community from Scott Healey, District Supervisor, MD/DE/DC Wildlife Services dated January 30, 2012.

Wenger, K.F. 1984. *Forestry Handbook,* New York: John Wiley and Sons.

Williams, S.C.; Ward, J.S. 2006. Exotic seed dispersal by white-tailed deer in southern Connecticut. *Natural Areas Journal*. 26(4): 383–390.

Phil Norman. Personal communication at the May 2011 *Maryland Suburban Deer Management Seminar* held by the U.S. Fish & Wildlife Service, University of Maryland Extension Service and USDA Wildlife Services.