Diversity and Abundance of Trees Within the Upland Forests of The Parris N. Glendening Preserve at Jug Bay

A Technical Report of the Jug Bay Wetlands Sanctuary

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Jug Bay Wetlands Sanctuary
1361 Wrighton Road
Lothian, MD 20711

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Abstract

The diversity, abundance and distribution of trees in level upland forests at the Glendening Nature Preserve at the Jug Bay Wetlands Sanctuary in Anne Arundel County, Maryland were described. Over 75% of the 48 upland tree species known to occur at the Sanctuary were identified from ninety-three 10 m by 10m plots, in addition to three new records for the Sanctuary: *Acer negundo* (box elder)*, Carya pallida* (pale hickory) and *Quercus coccinea* (scarlet oak). Of the 1011 trees measured 90% (n=914) were under 30 cm diameter at breast height. *Pinus virginiana* (Virginia pine) and *Quercus falcata* (southern red oak) were the dominant species in the plots. The distribution of *Acer rubrum* (red maple) and *Liquidambar styraciflua* (sweet gum)*,* both facultative wetland species, were found near seasonal wetlands and streams. Non-native invasive species, such as *Ailanthus altissima* (tree of heaven)occurred primarily along the edges and disturbed areas of the Preserve. Some deer browse was observed, yet our data were not sufficient to adequately assess the impact of deer population on forest regeneration. This analysis will assist in the refinement of the study and the understanding of tree diversity of other habitat types within the Sanctuary.

Introduction

For over twenty years staff and volunteers have conducted various research projects to document the plants and animals within the Jug Bay Wetlands Sanctuary. Most of the studies documented plant and animal diversity, ecological functions, as well as the role of wetlands in maintaining water quality.

Jug Bay Wetlands Sanctuary is a 566-hectare (1400 acre) ecological research station and wetland learning center located on the Patuxent River in southwest Anne Arundel County, Maryland, about 29 km (18 miles) south of Annapolis, in the Coastal Plain physiographic province. The Sanctuary is operated by the Anne Arundel County Department of Recreation and Parks, and is within Maryland's Chesapeake Bay National Estuarine Research Reserve.

The Sanctuary is comprised of three areas. The northern section is the Parris N. Glendening Nature Preserve; its western boundary is the Patuxent River, with Route 4 on the north, Plummer Lane on the east, and Wrighton Road on the South. This area is referred to as the "Preserve." The parcel south of Wrighton Road and north of Pindell Creek is referred to as the "Jug Bay Area." South of Pindell Creek is the Riggleman Preserve. The term "Sanctuary" is inclusive of all three areas. Figure 1 shows the boundaries of the Sanctuary.

Major habitats within the Sanctuary are fresh water tidal wetlands, non-tidal wetlands, upland hardwoods forests, managed meadows and fallow fields. Four permanent creeks (Two Run, Pindell, Wrighton and Galloway) drain the uplands and flow into the Patuxent River. Forests are the predominant upland habitat found throughout the Sanctuary. Due to recent grazing, mining and logging, some regions are young forests dominated by *Pinus virginiana* (Virginia pine)*, Sassafras albidium* (Sassafras)*,* and other early succession species. Other areas have mature open forests dominated by *Fagus grandifolia* (American beech)*, Carya tomentosa* (mockernut hickory), and *Quercus falcata* (southern red oak). Marshes and swamps are found along the river's edge and within the stream valleys floodplains.

This report focused on the Parris N. Glendening Nature Preserve (the Preserve). The 250-hectares (620 acre) contains a diversity of habitats: approximately 120 hectares of upland forests, while open fields cover 30 hectares, with wetlands and streams occupying the remaining 100 hectares. The Preserve is mostly a sandy level terrace 9 to 15 meters (30 to 50 feet) above the eastern shore of the Patuxent River. Generally, the soils are of the Galestown-Evesboro-Rumford Series and are well drained and very sandy (USDA SCS 1973). Late Pleistocene terrace deposits of sand, gravel, or silt clay underlie much of the area. Its most scenic western border is formed by the bluff and wetland edge of the river.

Several areas were identified that may influence the diversity, distribution, and abundance of tree species. The one-hectare area near the Sand Barrens and the 8-hectare Pine Barrens were newly re-forested areas and were dominated by *P. virginiana*, readily identified on the aerial photograph (Fig. 1).

Within the southeastern sections of the Preserve several nontidal wetlands occurred. A large depressional wetland, comprising the majority into southeastern portion of the Preserve," in addition to the headwaters of the creek flowing along the southern border, may harbor wetland tolerant species.

Past Land Use

Like many other parts of tidal Chesapeake Bay country post-European settlement, trees were cut for building purposes and land was cleared for agriculture. Many logging roads were established for harvesting timber and Galloway Creek still shows signs of an old millrace along its floodplain edge.

Southern Anne Arundel County was a strong tobacco agricultural region throughout the 17th and 18th centuries. Archaeological evidence shows that the Preserve land was graded/contoured and plowed for agriculture (unpub Maryland Archeology Site Survey 1989). Based on present day forest

cover, it was around the late 19th or early 20th century that much of the Preserve land was left fallow and succeeded to forest.

Although the 20th century brought much forest regeneration to the Preserve, human-caused changes were not finished. The northern end of the Preserve, because of its location along the Late Pleistocene terrace gravel beds, was the site of a sand and gravel quarry, approximately 5 hectares (12 acres) in size. The excavated area is still visible today in the topography and distinctive plant regeneration of the Sand Barrens. A horse farm operated along the Preserve's eastern edge until 2001, leaving about 16 hectares (40 acres) of meadow and a stand of evergreen trees referred to as the Pine Barrens.

The Preserve was a well-established hunting camp prior to County acquisition in 2001. Much of the area was leased to a hunting club, which used the old logging roads access their deer stands. Hunting continued until Jug Bay Wetlands Sanctuary acquired the property in 2001. It would not be unreasonable to expect a rise in deer population since the cessation of hunting on the Preserve. Deer have been found to reduce biological diversity in relatively low numbers (deCalesta and Stout 1997 in Rooney 2001). Deer influenced seedling growth and the density of understory vegetation (Cote et al 2004). We wanted to establish a base line data set to use to determine whether deer populations were influencing the regeneration of the forest.

To facilitate management efforts including the inventorying, monitoring and controlling non-native invasive species, non-native invasive plants were mapped. *Ailanthus altissima* (Tree of Heaven) was the non-native invasive tree of most concern.

The first study of habitats and tree diversity investigated three 10-m x 10-m plots in each of five different tree and shrub habitats in the Jug Bay area: Pine, Secondary, Hardwood, Floodplain, and Forested Swamp (Burke and Swarth 1997). They identified 52% of the tree and shrub species known to occur at the Sanctuary—32 tree species and 8 shrub species. The dominant species in the three upland habitats were *Liquidambar styraciflua* (sweet gum)*, Quercus* (all species combined), *S. albidium*, and *Acer rubrum* (red maple). Their research suggested that more samples were required to provide a thorough understanding of tree diversity and associated habitats.

Purpose of Study

When the Preserve was acquired by the state in 2001 and incorporated into the Jug Bay Wetlands Sanctuary, efforts were taken to document the species diversity and ecological communities. With the installation of a permanent 100-m grid system (see Methods section), we initiated a study to describe the diversity and distribution of plants and habitat types across the Preserve and the Jug Bay area.

This technical report summarizes results from the study conducted at the Glendening Preserve during 2004-2005. We described the diversity, distribution and abundance of trees found in the level upland forests. Field observations on the occurrence of non-native invasive plants and evidence of deer browse were our initial attempts to determine the extent of these threats to our forests.

Methods

A permanent 100-meter grid system was installed throughout the Jug Bay area and the Preserve in 2002 to more precisely map data collected. Surveyors from the Anne Arundel County Department of Public Works established the location of the grid, basing the coordinates on the UTM (Universal Transverse Mercator) lines, using a Trimble GPS unit. The points are located every 100 meters, at the junction of intersecting UTM lines a low, white PVC pipe (grid marker pole or GMP) was installed marked with its coordinates. UTM values were transposed to the coordinates from 500-544 where 500 is 4292700 meters north of the equator; 501 was 4292800 meters north of the equator,

etc. From west to east, letters were used with "A" representing to 351200 meters east in UTM zone 18E, "B" 351300 meters east in UTM zone 18E, etc.

Plant diversity and habitat data were collected from plots located at the grid marker poles. The plots were distributed throughout the 150-hectares of upland forest found within the Glendening Preserve. Plots were identified by their assigned latitude number and longitude letter, for example 533-O. At each grid pole, a temporary 10-m by 10-m plot was established, with the corners of the plot 7 m north, south, east, and west of the pole. A sketch, general habitat description and specific habitat characteristics were recorded. See Appendix A for the protocol and data sheet.

All trees within the plot were identified using several field guides (Brown and Brown 1972, Harlow 1959, Petrides 1986, Tiner 1988) using leaf and twig characteristics, as well as fruit and bark. For those greater than 4 cm in diameter, the diameter at breast height (DBH) was measured and recorded. Trees smaller than 4 cm DBH were identified to species or genus if possible and recorded as seedlings (first year plants) or saplings (young trees). Other woody and herbaceous species were identified and recorded.

In 2004 and 2005, teams of three to eight volunteers conducted the study weekly between May and October, surveying three to six plots each visit. Of the 164 plots surveyed within the Preserve only the 93 terrestrial forested plots that had a shallow slope (<4%) were included in this analysis. These plots, referred to as “level plots” (Fig. 2) were selected to reduce the data under analysis to a manageable size. Plots within the study area that were on slopes, along streams, or in depressional wetlands were excluded and will be evaluated in future reports.

Definition of a tree

We defined a tree as a woody plant that when mature, would grow to at least 4m tall; had only one erect perennial main stem or trunk; and had a definite crown shape. Specimens were placed into one of three categories: a measurable tree if the diameter at breast height (DBH) was at least 4 cm, sapling if it was under 4 cm DBH or several years old, and a seedling if it was very small and appeared to be a first year plant. Within the report, “tree” typically refers to a measurable tree. In most analysis, saplings and seedlings were combined under the category of “sapling.” Some small shrubs fell under our definition of a tree including *Aralia spinosa* (devil's walkingstick*), Hamamelis virginiana* (witch hazel*),* and *Kalmia latifolia* (mountain laurel*.)*

Effects of Deer Browse

We used the Maryland Cooperative Extension’s Fact Sheet 655 (Kays 2003) as a basis for investigating tree species susceptible to deer browse damage. While skewed in favor of landscape ornamentals, it contained some of the trees found during the study. The list was divided into four categories based upon the frequency of damage from deer browse: Rarely Damaged, Seldom Damaged, Occasionally Damaged and Frequently Damaged. Among the native tree species present in the Occasionally Damaged category and found in our level plots were *A. rubrum, Juniperus virginiana* (eastern red cedar)*, L. styraciflua* and several *Quercus* species—*Q. alba* (white oak)*, Q. prinus* (chestnut oak) and *Q. rubra* (northern red oak). We made the assumption that if deer preferred these species, then significant browse might result in an absence of their seedlings and saplings in a plot when measurable trees were present. Though a simplistic approach, it was not unrealistic (Rooney and Waller 2003, Rooney 2001.) For each of the species listed above we identified which plots had measurable trees present but lacked saplings. We compared these plots with those wherein deer browse had been observed directly, usually on herbaceous species or on vines such as *Smilax* (greenbriar) species.

Results and Discussion

Species Summaries

The following are summaries of the species found in the 93 plots, listed by scientific name and common name. The four letters in brackets is the species’ abbreviation used within each descriptive summary. The abundance status, described below, is given for each species, along with the total number of plots in which it occurred. Mean diameter at breast height (DBH) is listed in centimeters,

plus or minus the standard deviation, followed by the range. If the species was found in four or fewer plots, a list of other species found in the same plots are listed by their abbreviations. Other comments relevant to the plots or species are included. Appendix C provides additional information of which plots each species was found, in addition to the DBH of each tree.

Table 1. Description of JBWS Status

Abundant	Very numerous
Common	Often observed, may be Abundant in suitable habitat
Uncommon	Present in low numbers, may be Common in suitable habitat
Infrequent	Rarely encountered, only a few records, may be Uncommon in suitable habitat

Acer negundo L. Box Elder. [Ac ne] Infrequent. Eight trees in two plots (526-P and 531-W). Mean DBH=16.0 ±8.67, 4.5–29.8 cm. Found with Ac ru, Ai al, Li st, and Qu ph. New record for Sanctuary.

Acer rubrum L. Red Maple. [Ac ru] abundant. Present in 47.3% of the plots (44 of 93 plots). Sixty-eight trees in 19.4% of the plots (18 of 93 plots). Mean DBH=14.06 ±11.41, 4.2 – 61.0 cm. One plot (529-W) had twenty-one trees—31% of all *A. rubrum* measured! Six of the largest trees were Ac ru.

Ailanthus altissima Swingle. Tree of Heaven. [Ai al] uncommon. Non-native invasive species. Seven individuals in 5.4% of the plots (5 of 93 plots). Mean DBH=6.0 ±2.76, 4.1-12.0 cm. Two additional plots had seedlings and saplings only. See Map 10 for locations. Found in other locations outside of the plots, especially on the disturbed edges of the Sand Barrens and adjacent to roads.

Albizia julibrissin Durazz. Mimosa. [Al ju] infrequent. Non-native invasive. One individual (6.3 cm) found in plot 526-M near Wrighton Road parking area along with Ac ru, Co fl, Fa gr, Il op, Li tu, Pi vi, Sa al.

Amelanchier canadensis L. Medick. Serviceberry. [Am sp] uncommon. 7.5% of the plots (7 of 93 plots) had *Amelanchier canadensis* or *A. spp.* identified; none had a diameter larger than 4.0 cm.

Aralia spinosa L. Devil's Walkingstick. [Ar sp] uncommon. Six individuals in 5.4% of the plots (5 of 93 plots). Saplings or seedlings found in three other plots. Mean DBH=9.1 ±1.91, 4.0 – 9.1 cm.

Betula nigra L. River Birch. [Be ni] infrequent. Eight individuals in three plots (527-T, 532-S, and 532-T). Mean DBH=22.65 ±6.34, 16.0 - 30.5 cm. found with Ai al, Co fl, Ju vi, Li st, Li tu, Ny sy, Pr se, and Sa al. No seedlings or saplings were identified.

Carpinus caroliniana Walt. American Hornbeam. [Ca ca] uncommon. Three individuals (4.2 cm, 8.1 cm, 9.9 cm) in three plots (530-W, 534-L, 540-N) along with Ac ru, Ai al, Ar sp, Ca pa, Ca to, Fa gr, Il op, Ju vi, Li st, Li tu, Ny sy, Pi vi, Qu fa, Qu ru, and Sa al. Two additional plots (527-R and 529-W) had seedlings and saplings only.

Carya glabra (Mill.) Spach. Pignut Hickory. [Ca gl] infrequent. One seedling found in plot 535-M along with Ca to, Co fl, Fa gr, Il op, Qu al, Qu fa, Qu pr, Qu ru, and Qu ve.

Carya tomentosa (L.) Nutt. Ex Ell. Mockernut Hickory. [Ca to] abundant. Present in 49.5% of the plots (46 of 93 plots), forty-four trees were in 28.0% of the plots (26 of 93 plots). Mean DBH=10.97 ±7.26, 4.0-38.1 cm. One of the fifty largest trees was Ca to.

Carya pallida (Ashe) Engl. & Graebn. Pale Hickory. [Ca pa] infrequent. One individual (44.2 cm), which was one of the fifty largest trees. Occurred with Ac ru; Ca ca; Ca to; Il op; Ju vi; Li st; Li tu; Ny sy. New record for Sanctuary. Herbarium specimen (leaves and nuts) collected. 530-W.

Castanea pumila Mill. Chinquapin. [Ca pu] infrequent. Two trees in two plots, 534-M and 535-N (6.5 cm and 4.3 cm respectively) along with Ca to, Co fl, Fa gr, Il op, Li tu, Pi ta, Pi vi, Qu al, Qu fa, Qu ru, Ro ps, and Sa al. Saplings found in one other plot, 529-S.

Celtis occidentalis L. Hackberry. [Ce oc] infrequent. Two individuals in two plots, 525-P and 537-K, (17.7 cm and 14.5 cm, respectively) along with Ai al, Ar sp, Ju ni, and Pr se. A third plot, 530-U, had saplings only.

Cornus florida L. Flowering Dogwood. [Co fl] common. Fifty-seven trees in 35.5% of the plots (33 of 93 plots). Mean DBH=6.32 ±2.15, 4.0-15.0 cm. Five additional plots had seedlings or saplings.

Diospyros virginiana L. Persimmon. [Di vi] uncommon. One tree (4.2 cm in 532-O) and seedlings and saplings found in three additional plots, 527-N, 535-M, and 535-Q. Found along with Ac ru, Am sp, Ca to, Fa gr, Il op, Ny sy, Pi vi, Qu al, Qu fa, Qu pr, and Sa al.

Fagus grandifolia Ehrh. American Beech. [Fa gr] abundant. Second-most abundant tree within the plots, and found in the most plots: 74.2% of the plots (69 of 93 plots). 172 individuals in 57.0% of the plots (53 of 93 plots). Sixteen other plots (17.2% of the plots) had only seedlings or saplings. Mean DBH=11.28 ±9.19, 4.0-50.5 cm. Six of the fifty largest trees were Fa gr.

Ilex opaca Ait. American Holly. [Il op] abundant. Found in 51.6% of the plots (48 of 93 plots), yet only five plots (5.4%) had a total of ten measurable trees. Mean DBH=19.4 ±4.65, 4.0-19.4 cm.

Juglans nigra L. Black Walnut. [Ju ni] infrequent. Three individuals in plots 532-U and 537-K. (8.1 cm, 21.8 cm, 25.5 cm) in association with Ai al, Ca to, Ce oc, Li st, Li tu, and Sa al.

Juniperus virginiana L. Eastern Red Cedar. [Ju vi] common. Fifteen trees found within 10.8% of the plots (10 of 93 plots). Seedlings and saplings were found in an additional ten plots (10.8%). Mean DBH=10.68 ±6.85, 4.4 – 32.8 cm.

Kalmia latifolia L. Mountain Laurel. [Ka la] infrequent. No individuals greater than 4.0 cm were found in the Level Plots, although saplings or seedlings were in four plots, 528-Q, 532-M, 539-M, and 539-N. Found along with Ac ru, Am sp, Ar sp, Ca to, Co fl, Fa gr, Il op, Ju vi, Li st, Li tu, Ny sy, Pi vi, Pr se, Qu al, Qu fa, Qu pr, and Sa al. The level upland forest was marginal habitat for Ka la, it prefers the steep slopes along the streams and river.

Liquidambar styraciflua L. Sweet Gum. [Li st] common. Forty trees found in 19.4% of the plots (18 of 93 plots). Seedlings and saplings found in fifteen other plots (16.1% of the plots). Mean DBH=12.29 ±8.14, 4.0 - 38.5 cm. One of the fifty largest trees was Li st.

Liriodendron tulipifera L. Tuliptree. [Li tu] common. Thirty-seven individuals in 22.6% of the plots (21 of 93 plots). Seedlings and saplings were found in another seventeen plots (18.3% of the plots). Mean DBH=21.34 ±13.92, 4.2 - 48.2 cm. Eight of the fifty largest trees were Li tu.

Magnolia virginiana L. Sweetbay [Ma vi] infrequent. Identified in one plot, but was under 4.0 cm, 529-R. Found with Ac ru, Am ca, Ca to, Fa gr, Il op, Li st, Ny sy, Qu ru, Qu ve, and Sa al.

Nyssa sylvatica Marsh. Sour Gum. [Ny sy] common. Thirty-one trees found in 18.3% of the plots (17 of 93 plots). Seedlings and saplings were identified in eight additional plots (8.6% of the plots). Mean DBH=10.65 ±6.9, 4.0 – 32.6 cm.

Pinus taeda L. Loblolly Pine. [Pi ta] infrequent. Seedlings found in three plots, 533-M, 535-N, 539-K, but no individuals were over 4.0 cm. Mature specimens are known from a few other locations on the Sanctuary. Other species in the plots were Ac ru, Ca to, Ca pu, Co fl, Di vi, Fa gr, Il op, Ny sy, Pi vi, Qu al, Qu fa, Qu ru, and Sa al.

Pinus virginiana P. Mill. Virginia Pine. [Pi vi] abundant. The most abundant species, with 205 individuals in 48.4% of the plots (45 of 93 plots), with a mean DBH=18.0 ±9.17, 4.0 – 57.6 cm. Four other plots had seedlings or saplings only. One plot (534-Q) had thirty trees. Five of the fifty largest trees were Pi vi.

Populus grandidentata Michx. Bigtooth Aspen. [Po gr] infrequent. Six individuals in one plot, 539-L, (mean DBH=21.5 ±8.67, 10.7 - 32.5 cm) along with Ac ru, Ca to, Fa gr, Pi ta, Pi vi, Qu fa, Il op, Ju vi, Qu al, Qu fa, and Sa al.

Prunus serotina Ehrh. Wild Black Cherry. [Pr se] uncommon. Eleven trees in 8.6% of the plots (8 of 93 plots). Seedlings and saplings were in eight additional plots. Mean DBH=13.18 ±10.09, 4.2 – 41.0 cm. One of the fifty largest trees was Pr se.

Quercus alba L. White Oak. [Qu al] common. Twenty-three trees in 16.1% of the plots (15 of 93 plots). Seedlings and saplings in fourteen other plots (15.1% of the plots). Mean DBH=14.83 ±10.8, 4.0 – 37.3 cm. One of the fifty largest trees was Qu al.

Quercus coccinea Wang. Scarlet Oak. [Qu co] infrequent. One individual in 533-O (40.5 cm. with Ca to, Co fl, Fa gr, Il op, Qu al, Qu ru, and Sa al. Acorns were present for identification. This specimen was one of the largest trees in the study.

Quercus falcata Michx. Southern Red Oak. [Qu fa] abundant. 109 trees in 39.8% of the plots (37 of 93 plots). Two additional plots had seedlings or saplings only. Mean DBH=19.42 ±11.33, 4.2 – 63.3 cm. Twelve of the fifty largest trees were Qu fa.

Quercus marilandica Meunchh. Black-jack Oak. [Qu ma] infrequent. Four individuals in 536-M (7.2, 7.5, 7.6, 13.4 cm) along with Ac ru, Co fl, Fa gr, Il op, Ju vi, Li tu, Ny sy, Pi vi, and Qu fa. Seedlings and saplings were found in this plot and an additional plot, 526-N.

Quercus phellos L. Willow Oak. [Qu ph] uncommon. Five individuals in three plots, 525-M, 529-T, and 530-R. along with Ac ru, Fa gr, Il op, Li tu, Pi vi, Pr se, Qu fa, and Sa al. Mean DBH=16.3 ±6.77, 11.1 - 26.4 cm Eight other plots had saplings or seedlings, yet no saplings or seedlings were found in plots with measurable trees.

Quercus prinus Montana Willd. Chestnut Oak. [Qu pr] uncommon. Eight individuals in 6.5% of the plots (6 of 93 plots). Four additional plots (4.3% of the plots) had seedlings or saplings. Mean DBH=19.26 ±14.53, 6.2 - 47.9 cm. One of the fifty largest trees was Qu pr.

Quercus rubra L. Northern Red Oak. [Qu ru] common. Twenty-eight trees in 18.3% of the plots (17 of 93 plots). Three additional plots had seedlings or saplings. Mean DBH=18.53 ±11.21, 7.1 – 50.8 cm. One of the fifty largest trees was Qu ru.

Quercus stellata Wangenh. Post Oak. [Qu st] infrequent. Two individuals in two plots, (13.5 cm and 36.1 cm in 530-R and 532-N, respectively). The individual in 532-N was one of the fifty largest trees. Found with Ac ru, Ca to, Co fl, Fa gr, Li tu, Ny sy, Pi va, Qu al, Qu fa, Qu ph, Qu pr, Qu ru, and Sa al.

Quercus velutina Lam. Black Oak. [Qu ve] uncommon. Thirteen individuals in 6.5% of the plots (6 of 93 plots). Two plots had seedlings and saplings only. Mean DBH=15.58 ±9.32, 4.2 - 38.5 cm. One of the fifty largest trees was Qu ve.

Robinia pseudo-acacia L. Black Locust [Ro ps] infrequent. Three individuals (25.2 cm, 11.5 cm, 29.4 cm) identified in two plots, 526-O and 534-M, with seedlings identified in a third plot, 533-Q. Found with Ac ru, Ca to, Ca pu, Fa gr, Il op, Ju ni, Ju vi, Li tu, Pi vi, Qu fa, Qu ru, Qu sp, Qu ve, and Sa al

Sassafras albidum (Nutt.) Nees. Sassafras. [Sa al] abundant. Sixty-six trees in 31.1% of the plots (29 of 93 plots). Seedlings and saplings were found in another 23.7% of the plots (22 of 93 plots). Mean DBH=8.77 ±4.75, 4.0 – 25.6 cm.

Species Diversity

Of the 48 upland tree species identified through previous studies and casual observation at the Sanctuary, 36 (75%) species were found in the Level Plots (Table 2). Five of these species were found as only seedlings or saplings, or did not measure at least 4 cm in diameter: *Amelanchier canadensis* (serviceberry)*, C. glabra, K. latifolia, Magnolia virginiana* (swamp magnolia)*,* and *Pinus taeda* (loblolly pine). In addition, three species not currently on the list were identified: *Acer negundo* (box elder)*, Carya pallida* (pale hickory) and *Quercus coccinea* (scarlet oak).

Two trees were not positively identified to either genus or species, so they were excluded from most analysis. The identification of *Q. muhlenbergii* had not been verified, and was included in the

Quercus sp. category; possible identifications included *Q. prinus, Q. prinoides,* or *Q. michauxii* (swamp chestnut oak).

Eleven species were not found within the level plots: *Aronia arbutfolia* (red chokeberry)*, Asimina triloba* (pawpaw)*, Cercis canadensis* (redbud)*, Chioanthus virginicus* (fringetree)*, Fraxinus americana* (white ash)*, Fraxinus pennsylvanica* (green ash)*, H. virginica, Hydrangea arborescens* (wild hydrangea)*, Q. michauxii, Ulmus americana* (American elm)*,* and *Ulmus rubra* (slippery elm)*.* They may have a sparse or patchy distribution, which may be why we did not encounter them in these 10-m, plots. Their preferred habitat may be associated with slopes, stream valleys, or depressional wetlands, which were excluded from this analysis. Species considered Obligate Wetland Plants per Tiner (1988) were not found in the level plots confirming our identification the plots as upland habitats.

Species diversity within any one plot was not high, the mean number of species was 7.4±2.5; rarely were more than nine species or nine genera found (Table 3 and Fig. 3a and 3b.) A maximum of twelve of the 39 species were found within only four plots. No single plot contained more than 31% of the species.

In total, 39 species of 27 genera were identified. Four of the genera had multiple species, including *Acer* (2), *Carya* (3), *Pinus* (2) and *Quercus* (9.) A maximum of eleven of the 27 genera were found in only three plots. No single plot contained more than 41% of all the genera observed although 68% contained six or more genera.

Table 2. Trees of the Jug Bay Wetlands Sanctuary.

Thirty-nine species of trees were identified within the Level Plots at the Glendening Preserve. Three species were new records for the Sanctuary (highlighted).

DBH=Diameter at Breast height
Status criteria are described in Table 1.
* Shrubs and small trees included if they could have a dominant trunk over 4cm in diameter

✠ were found as measurable trees within the Preserve Level Plots

♦ were only found as seedlings or saplings and no measurable trees.

Status	Common Name	Scientific Name	Found in Plot	Number of Trees Measured	Max. DBH (cm)	Mean DBH (cm) ±St dev.
Infrequent	Box Elder	*Acer negundo*	✠	8	29.8	15.99 ±8.67
Abundant	Red Maple	*Acer rubrum*	✠	68	61.0	14.06 ±11.41
Uncommon	Tree of Heaven (nonnative)	*Ailanthus altissima*	✠	7	12.0	5.97 ±2.76
Infrequent	Mimosa (nonnative)	*Albizia julibrissin*	✠	1	6.3	-
Uncommon	Serviceberry	*Amelanchier canadensis*	♦			
Uncommon	Devil's Walkingstick *	*Aralia spinosa*	✠	6	9.1	5.30 ±1.91
Infrequent	River Birch	*Betula nigra*	✠	8	30.5	22.65 ±6.34
Uncommon	American Hornbeam *	*Carpinus caroliniana*	✠	3	9.9	7.40 ±2.91
Infrequent	Pignut Hickory	*Carya glabra*	♦			
Infrequent	Mockernut Hickory	*Carya tomentosa*	✠	44	38.1	10.97 ±7.26
Infrequent	Pale Hickory	*Carya pallida*	✠	1	44.2	-
Infrequent	Chinquapin	*Castanea pumila*	✠	2	6.5	5.40 ±1.56
Infrequent	Hackberry	*Celtis occidentalis*	✠	2	17.7	16.10 ±2.26
Common	Flowering Dogwood *	*Cornus florida*	✠	57	15.0	6.32 ±2.15
Uncommon	Persimmon	*Diospyros virginiana*	✠	1	4.2	-
Abundant	American Beech	*Fagus grandifolia*	✠	172	50.5	11.28 ±9.19
Abundant	American Holly	*Ilex opaca*	✠	10	19.4	6.76 ±4.65
Infrequent	Black Walnut	*Juglans nigra*	✠	3	25.5	18.47 ±9.17
Common	Eastern Red Cedar	*Juniperus virginiana*	✠	15	32.8	10.68 ±6.85
Uncommon	Mountain Laurel *	*Kalmia latifolia*	♦			
Common	Sweet Gum	*Liquidambar styraciflua*	✠	40	38.5	12.29 ±8.14
Common	Tuliptree	*Liriodendron tulipifera*	✠	37	48.2	21.34 ±13.92
Infrequent	Swamp Magnolia	*Magnolia virginiana*	♦			
Common	Sour Gum	*Nyssa sylvatica*	✠	31	32.6	10.65 ±6.90
Infrequent	Loblolly Pine	*Pinus taeda*	♦			
Abundant	Virginia Pine	*Pinus virginiana*	✠	205	57.6	18.00 ±9.17

Infrequent	Bigtooth Aspen	*Populus grandidentata*	✠	6	32.5	21.52 ±8.67
Uncommon	Wild Black Cherry	*Prunus serotina*	✠	11	41.0	13.18 ±10.09
Common	White Oak	*Quercus alba*	✠	23	37.3	14.83 ±10.80
Infrequent	Scarlet Oak	*Quercus coccinea*	✠	1	40.5	-
Abundant	Southern Red Oak	*Quercus falcata*	✠	109	63.3	19.42 ±11.33
Infrequent	Black-jack Oak	*Quercus marilandica*	✠	4	13.4	8.92 ±2.99
Uncommon	Willow Oak	*Quercus phellos*	✠	5	26.4	16.32 ±6.77
Uncommon	Chestnut Oak	*Quercus prinus*	✠	8	47.9	19.26 ±14.53
Common	Northern Red Oak	*Quercus rubra*	✠	28	50.8	18.53 ±11.21
Infrequent	Post Oak	*Quercus stellata*	✠	2	36.1	24.8 ±15.98
Uncommon	Black Oak	*Quercus velutina*	✠	13	38.5	15.58 ±9.33
	Unknown Oak	*Quercus sp.*	✠	11	39.0	20.12 ±12.60
Infrequent	Black Locust	*Robinia pseudo-acacia*	✠	3	29.4	22.03 ±9.36
Abundant	Sassafras	*Sassafras albidum*	✠	66	25.6	8.77 ±4.75

Table 3. Summary of Plots, including Number of Species, Number of Trees, and Diameter range. *S/S: Some species were not found as measurable trees but only as seedlings or saplings.

Plot	Number of Species	Species with *S/S only	Number of Trees	Max DBH	Mean DBH
525-M	9	2	19	30.8	14.3
525-N	8	4	18	30.1	12.2
525-O	4	0	7	32.7	16.7
525-P	3	1	2	41.0	29.3
525-Q	3	2	7	37.4	19.1
526-M	8	3	10	57.6	17.55
526-N	8	3	19	35.0	15.2
526-O	6	2	7	32.8	19.07
526-P	3	1	7	27.0	13.9
526-R	7	3	10	44.0	24.47
526-S	8	4	22	46.3	17.9
526-T	7	3	17	29.2	14.3
527-N	6	3	5	50.8	29.62
527-R	12	6	7	42.5	26
527-T	2	0	4	30.5	22.5
528-Q	12	4	19	33.5	10.6
528-S	8	2	12	42.4	16.1
528-T	7	5	15	32.6	13.9
529-M	9	4	18	20.2	10.9
529-N	4	1	15	28.7	11.09
529-O	9	6	4	40.9	25.6
529-Q	9	1	13	28.9	9.6
529-R	12	7	12	29.3	12.7
529-S	8	6	4	27.5	17.6
529-T	8	3	10	26.4	15.8
529-U	8	3	13	39.0	14.6
529-W	5	2	25	22.7	11.7
530-K	8	1	13	45.0	14.9
530-L	7	1	9	41.5	15.8
530-M	10	3	15	29.3	12.6
530-Q	10	7	4	48.2	30
530-R	10	2	19	32.2	13.2
530-T	4	2	5	41.1	22.28
530-U	4	1	6	38.5	13.75
530-W	9	4	7	44.2	22.04
531-L	7	2	14	22.5	15.65
531-M	7	2	14	19.3	12.05
531-N	4	0	10	48.8	16.97
531-P	9	3	23	17.5	9.9
531-R	6	4	16	37.1	13.98
531-W	3	0	7	61.0	25.9
532-L	6	2	14	26.5	12.6
532-M	10	1	14	16.6	9.8
532-N	7	2	8	36.1	16.3
532-O	12	5	15	40.8	9.35
532-P	12	4	21	32.5	9.17
532-Q	9	2	14	34.4	9.29
532-R	3	2	2	4.9	4.85
532-S	6	2	9	28.9	13.35
532-T	6	2	10	18.7	12.55
532-U	5	2	4	38.1	23.55
533-L	4	1	10	46.3	15.39
533-M	8	5	8	26.7	11.92
533-N	8	4	7	12.0	7.64
533-O	8	2	11	40.5	13.98
533-P	8	3	6	39.5	21.23
533-Q	9	5	11	63.3	17.23
533-R	7	5	14	25	13.82
533-S	6	4	4	30.8	26.12
534-L	10	3	15	24.7	13.6
534-M	7	1	14	29.4	12.22
534-N	9	2	23	17.4	8.16
534-O	8	5	13	30.5	12.55
534-Q	6	5	30	18.2	10.37
534-R	7	6	5	30.1	20.56
535-L	8	4	6	47.9	23.78
535-M	11	6	11	38.5	17.7
535-N	10	2	12	29.8	14.4
535-O	4	1	5	50.5	23.44
535-P	5	3	4	36.6	32.37
535-Q	10	6	7	34.3	12.69
536-L	8	2	9	37.8	12.4
536-M	10	2	17	27.5	11.85
536-N	6	2	10	19.7	9.4
536-O	7	3	9	33.3	8.65
536-P	11	3	16	35.1	10.95
537-K	3	1	2	21.8	18.15
537-L	7	1	9	45.3	15.37
537-M	8	4	12	29.9	14.57
537-N	9	6	7	37.8	19.98
537-O	10	7	3	43.5	37.9
538-L	7	3	5	46.6	22.94
538-M	9	3	19	28.5	13.04
538-N	7	1	16	33.3	14.16

539-K	6	5	8	23.1	11.88
539-L	11	3	22	32.5	13.51
539-M	9	4	7	38.0	17
539-N	8	4	10	30.4	14.75
540-K	1	1	2	9.4	8.1
540-M	6	5	6	44.8	28.76
540-N	12	3	15	29.3	10.2

Of the 93 plots, 73% contained six or more genera, with 56% containing between 6 and 8 genera. This compared with 77% of the plots containing six or more species, with 46% having between 6 and 8 species. Only four plots contained 2 or fewer genera; five plots contained 2 or fewer species. As shown in Figure 4, six genera were found in more than half of the plots, with *Quercus* and *Fagus* distinctly more widespread than any of the other. Fourteen genera were found in fewer than eleven plots. Three genera (*Albizia, Magnolia,* and *Populus*) occurred in only one plot; *Juglans* was found in two plots; *Betula, Castenea, Celtis*, and *Robinia* were found in three; and *Diospyros*, was found in four plots. Five other genera (*Ailanthus, Amelanchier, Aralia, Carpinus, and Kalmia*) each occurred in eleven or fewer plots.

The majority of species (69%) occurred in fewer than 25% of the plots (Table 3 and Fig. 5) while five species (*F. grandifolia* (69 plots,) *S. albidium* (51 plots,) *P. virginiana* (49 plots,) *Ilex opaca* (American holly) (48 plots,) and *C. tomentosa* (46 plots,) occurred in over 50% of the plots.

Species Abundance and Distribution

Distribution and abundance maps were generated for the most common species. These maps included plots that contained either measurable trees, saplings or seedlings.

Five species—*P. virginiana* (205 trees,) *F. grandifolia* (172 trees,) *Q. falcata* (109 trees,) *A. rubrum* (68 trees,) and *S. albidium* (66 trees) —comprised 63% of the 1,011 measurable trees recorded in the level plots (Fig. 6) Of these, only *A. rubrum* was not among the most frequently encountered during the study (Figure 3).

F. grandifolia (Fig. 5) was found throughout the Preserve in 74.2% of the plots (69 of 93 plots). 172 individuals in 57.0% of the plots (53 of 93 plots). Sixteen other plots (17.2% of the plots) had only seedlings or saplings.

P. virginiana (Fig. 8) was widely distributed; 205 trees found in 48.4% of the plots (45 of 93 plots), with 62% of these plots (28 of 45 plots) having more than three individuals.

Q. falcata (Fig. 9) was identified in 41 plots. The majority of the 109 individuals found occurred in the northern section of the Preserve.

Many of the 41 plots with *A. rubrum* were concentrated in the southeast section of the Preserve (Fig. 10). This region contained several depressional wetlands, including a large vernal pool that was over 1-hectare. The hydrological regime may account for the skewed distribution, as would be expected for this facultative wetland species (Tiner 1988). All plots, except for 529-W that had 21 trees and 526-S with 9 trees, had fewer than 4 trees.

S. albidium occurred throughout the Preserve, in 55% (n=51) of the plots, with 66 measurable trees (Fig. 11a). The distribution was similar to *P. virginiana*, although they were infrequently found in the same plots. *P. virginiana* was found in only 37% of the nineteen plots where *Sassafras* was found.

C. tomentosa was the most common hickory, with 44 trees, and found in 53% (n=46) of the plots. Two other *Carya* species were identified, *C. pallida* (one tree) and *C. glabra* (sapling smaller than 4 cm DBH). Most *Carya* saplings and seedlings were difficult to identify to species. Therefore, in Figure 11B all hickories were mapped, regardless of species.

I. opaca was found throughout the Preserve in 52% (n=48) of the plots. Yet very few measurable trees (n=10) were found in the plots (Fig. 11C). Burns and Honkala (1990) indicated that larger specimens were found in stream bottoms and grew best in moist soils so our plots may not be representative of its optimal habitat.

Cornus florida (flowering dogwood) was found in 57% (n=38) of the plots. A total of 57 trees were found, although it was frequently found as a tree smaller than 4 cm DBH or as a sapling (Fig. 11D).

Liriodendron tulipifera (tuliptree) has been found to grow well where the soils are moderately moist, well drained, and loose textured (Burns and Hokala 1990). Most of the 37 trees were found in plots located near the streams, river bank, and depressional wetlands In the level plots of the Preserve *L. tulipifera* was found in 41% of the plots (n=38); (Fig. 11E).

Burns and Hokala (1990) described the preferred habitat of *L. styraciflua* in Maryland as “alluvial swamp sites and on imperfectly and poorly drained soils having a high clay content” They further ascertained that it rarely grew well on “clay or gravelly clay upland soils and [was] rarely found on well-drained, sandy soils.” The distribution of all but 7 of the 40 trees occurred in 18 plots in the southeastern portion of the Preserve where the habitats were either depressional wetlands or the headwaters of streams (Fig. 11F).

The distribution of the 31 *Nyssa sylvatica* (sour gum) trees found in 18.3% of the plots (17 of 93 plots) appeared to occur on a gradient running from northwest to southeast (Fig. 11G). This pattern may be related to streams and vernal pools as Burns and Hokala (1990) identified stream bottoms as the preferred habitat. One of the five *Nyssa* individuals found in plot 528-T was among the top 100 largest trees (Appendix B), with a DBH of 32.6 cm.

J. virginiana was found in almost 22% of the plots (Fig. 11H) yet only one plot had more than 3 trees (mean number of trees=0.8 ±1.4, range 0-6 trees). It was not as common as we expected based on the young age of the forests and the prevalence of *P. virginiana*. *J. virginiana* was found in only seven of the fifty plots (14%) where *P. virginiana* occurred. *J. virginiana* was one of the few species that showed a distribution strongly associated with the old fields near grid marker pole 533-R.

Prunus serotina (wild black cherry), an early successional species, was found primarily in edge habitats—between the barrens and the forests and along Wrighton Road (Fig. 11I.) Interestingly, the individual found in 525-P was among the fifty largest trees (Table 4a) with a DBH of 41.1 cm

Quercus: Diversity, Abundance and Distribution

The diversity of oak species for which the Eastern Deciduous Forests are known, were well represented within this study; 20% of the trees were of the *Quercus* genus. Nine species were identified (Fig. 12) with *Q. falcata, Q. rubra,* and *Q. alba* representing more than 82% of all the *Quercus*. Of the 93 plots, 77% (n=72) had at least one representative of the *Quercus* genus, as a measurable tree, sapling, or seedling (Fig. 13). Three plots contained four different species of *Quercus*, while ten plots had three different *Quercus* species.

Quercus were found in all DBH size ranges from the minimum measurement of 4.0 cm up to the largest tree in the study, 63.3 cm (*Q. falcata*.) The vast majority (64%) of individuals were under 20.0 cm DBH (Fig. 14) while 32% were between 20.1 cm and 40.0 cm.

One unusual finding was that the distribution of *Q. alba* and *Q. rubra* had very little overlap (Fig. 15). Both species were found in a small proportion of the plots—*Q. alba* in 14 plots (15%) and *Q. rubra* in 18 plots (19%)—and only four of these plots (14%) had both species. *Q. alba* can tolerate drier conditions (Burns and Honkala 1990) that may have accounted for the differences in where each species occurred. Future investigations will be required to determine whether this or other factors account for their disparate distribution.

Big Trees

The fifty largest trees, as measured by their DBH, were found in 37 plots (Fig. 16A-B and Table 4A) with five species comprising 37 of these trees (Table 4A-B). Diameter at breast height ranged from 35.7-63.3 cm (Mean DBH=43.3±6.3). These trees were by no means the largest trees on the Preserve. Twenty-one other trees have been found, outside of the Level Plots, which exceed 1.0 m DBH.

Table 4a. Diameter of the Fifty Largest Trees, Ranked by Diameter at Breast Height (DBH). The rest of the top 100 trees can be found in Appendix B

Species	DBH	Plot		Species	DBH	Plot		Species	DBH	Plot
Quercus falcata	63.3	533 Q		Fagus grandifolia	43.5	537 O		Liquidambar styraciflua	38.5	530 U
Acer rubrum	61.0	531 W		Pinus virginiana	42.5	527 R		Carya tomentosa	38.1	532 U
Pinus virginiana	57.6	526 M		Quercus falcata	42.4	528 S		Quercus falcata	38.0	539 M
Quercus rubra	50.8	527 N		Pinus virginiana	41.5	530 L		Quercus spp	37.8	536 L
Fagus grandifolia	50.5	535 O		Fagus grandifolia	41.1	530 T		Quercus falcata	37.8	537 N
Acer rubrum	49.0	525 Q		Prunus serotina	41.0	525 P		Acer rubrum	37.4	525 Q
Fagus grandifolia	48.8	531 N		Quercus rubra	40.9	529 O		Quercus alba	37.3	537 N
Liriodendron tulipifera	48.2	530 Q		Pinus virginiana	40.8	532 O		Quercus falcata	37.1	533 L
Quercus prinus	47.9	535 L		Quercus coccinea	40.5	533 O		Quercus falcata	37.1	531 R
Liriodendron tulipifera	46.6	538 L		Acer rubrum	39.5	530 W		Liriodendron tulipifera	36.9	526 S
Liriodendron tulipifera	46.3	526 S		Fagus grandifolia	39.5	533 P		Quercus falcata	36.9	537 O
Quercus falcata	46.3	533 L		Quercus falcata	39.4	538 L		Fagus grandifolia	36.6	535 P
Quercus falcata	45.3	537 L		Liriodendron tulipifera	39.3	526 R		Quercus stellata	36.1	532 N
Liriodendron tulipifera	45.0	530 K		Liriodendron tulipifera	39.1	526 R		Acer rubrum	35.8	531 W
Quercus falcata	44.8	540 M		Quercus spp	39.0	529 U		Acer rubrum	35.7	531 W
Carya pallida	44.2	530 W		Quercus velutina	38.5	535 M		Quercus falcata	35.7	533 P
Liriodendron tulipifera	44.0	526 R		Pinus virginiana	38.5	529 U				

Table 4b. Summary of Species that had more than 5 trees greater than 35.5 cm DBH

Species	Number of Trees	Min DBH (cm)	Mean DBH (cm)	Max DBH (cm)
Quercus falcata	12	35.7	42.01	63.3
Liriodendron tulipifera	8	36.9	43.18	48.2
Fagus grandifolia	6	36.6	43.33	50.5
Acer rubrum	6	35.7	43.07	61.0
Pinus virginiana	5	38.5	44.18	57.6

The majority (90%) of the trees were small; we had almost one hundred trees larger than 30 cm DBH (Appendix B). Figure 16B described the range of DBH of the most frequently encountered species. Some species rarely exceed 20 cm DBH at maturity, such *S. albidium*, *C. florida* and *I. opacum*, but even these small trees were generally smaller than 10 cm DBH.

We would expect younger forests to contain small trees of pioneer species or many individuals but of small size. Conversely, mature forests would contain relatively few large trees, with a few smaller shade-tolerant trees. There was no correlation between number of trees per plot and the largest DBH found within the plot (Fig. 17 and Table 3; Pearson Rank Correlation = 0.31). For example, for the fourteen plots with seven trees, the maximum DBH ranged from 19 to 47 cm (Mean DBH=33±8.5.) The plot with our largest tree (*Q. falcata*, 63.3 cm in 533-Q) had eleven trees—the mean number of trees found in all level plots—of nine different species, greater than the average number of species (7.4±2.5) of all plots combined.

The lack of correlation between DBH and number of tress in a plot may be due to the prior use of the site for cattle grazing or home sites, where single trees were left to mark property lines or provide shade. As the fallow fields regenerated into forests, smaller trees would surround the large trees.

Interestingly, the majority (80%) of large trees had neither seedlings nor saplings in their corresponding plots. Only *F. grandifolia*, *Q. alba* and *Q. prinus* had seedlings and saplings on their respective plots.

Future investigations will be required to better explain the diversity in DBH and tree density within the Preserve, as well as what factors accounted for a lack of seedlings within plots with large trees.

Variations Between Plots: Species Diversity and Abundance

In this analysis, only measurable trees were included in the analysis. Most plots had between 6-10 trees (range=0-30 trees; mean 11.1±5.9; Figure 10), yet the similarity of the plots to each other was not great. The range of number of trees, number of species, and species diversity within any one plot varied greatly. (Fig. 18, Table 3 and Appendix D). No apparent pattern emerged to explain the difference, with the exception of the dominance of evergreen species found near open meadows.

Only 32% of the 93 level plots had a dominant species, defined as one species representing 50% or more of the measurable trees within the plot. Twelve different species were dominant (Figure 19A-B). As would be expected based on their abundance and frequency, the most common species were the dominant tree within some of their plots. *P. virginiana* was the dominant species in nine plots (and in four of these it was the only tree species.) *F. grandifolia* was dominant in six plots. *Q. falcata* was the dominant species in four plots—in one plot (540-M) it was the only tree species.

Ailanthus altissima (tree of heaven) was found in only five plots, but was dominant in one, 532-R, and both individuals were under 5.0 cm. *A. negundo* and *Betula nigra* (river birch) were infrequently encountered during the study (found in two and three plots, respectively) yet each was the dominant species in one of their plots. Conversely, *C. tomentosa* and *L. tulipifera* were often encountered, yet never were the dominant species in their plots. Future investigations into their habitat preferences or life history would shed light on their distribution and abundance.

Deer Browse and Effects on Forest Regeneration

The absence of seedlings and saplings of species susceptible to deer browse pressure (Kays 2003) along with our observations of deer browse damage was used to investigate deer browse pressure, summarized in Figure 20.

For plots with *J. virginiana* and *A. rubrum* most (80%) lacked saplings. No browse was noted so other factors may be responsible for the lack of saplings. For *J. virginiana* The lack of saplings would be expected, being an early successional species with limited germination in the shade. It

was unclear why there were few *A. rubrum* saplings. It may have been due to deer browse or other unknown factors influencing germination and survival.

The case was otherwise among the *Quercus* species for which saplings appeared in many of the plots. In evaluating only the plots containing measurable trees of *Q. alba, Q. falcata* and *Q. rubra,* we observed a paucity of saplings and noticeable deer browse. This was most evident for *Q. falcata*. Of the 37 plots, 46% (17 plots) had noticeable deer browse, while 47% (8 of 17 plots) of these "deer browse" plots had trees present but no *Q. falcata* saplings. Deer browse may have affected regeneration in 22% (8 of 37) of the plots containing *Q. falcata. For Q. alba* and *Q. rubra* plots, no conclusion could be made because in each case only one plot had browse observed directly.

Correlation of noticeable deer browse on plants and presence of saplings within the plots may not be a reliable indicator of the impact of deer population. The variations within the presence and absence of *Quercus* saplings requires further investigation as to whether lack of seedlings was due to deer population pressure, natural variations within the species, or factors relating to the relative age of the forest. This comparison raised the question of why *Q. alba* had so many more seedlings or saplings than either *Q. falcata* or *Q. rubra.* The challenge of identifying oak saplings to species may have skewed these results. Unfortunately, this study design was not adequate for fully analyzing the impacts of deer population on forest ecology.

Non-native invasive species

As shown in Figure 21, plots with non-native invasive species were located adjacent to roads and disturbed areas, along the perimeter of the Preserve. Although only identified in seven plots, previous investigations throughout the Preserve found *A. altissima* prevalent along the perimeter of the study area. *Albizia julibrissin* (mimosa) another non-native invasive tree was found in one plot. Other non-native invasive shrubs, vines and herbaceous plants documented included *Rosa multiflora* (multiflora rose,) *Celastrus orbiculatus* (oriental bittersweet) *Lonicera japonica* (Japanese honeysuckle) and *Microstegium vimineum* (Japanese stiltgrass.) Unfortunately, we also identified new records of non-native invasive plants for the Sanctuary, including *Ligustrum spp*. (privet,) *Morus alba* (white mulberry,) and *Hedera helix* (English ivy.) Subsequent projects were developed to better document the diversity and distribution of non-native species.

Summary

This study documented the diversity and distribution of most of the upland tree species. Prior to this study 48 species of upland trees had been identified on the Sanctuary. Conducting 10-m by 10-m plots in upland forests identified 75% of the species and added three new species for the list. This analysis demonstrated the effectiveness of sampling widely distributed plots to document diversity.

Restricting this analysis to only terrestrial level plots, specific habitat types were excluded, such as wetlands, stream banks and slopes, where the other 25% of species may occur. Considering that the species not found were facultative wetland species the lack of wetland habitats in the analysis could explain this. Evaluation of all 164 plots is required to determine if the study adequately captures the species diversity of the Preserve. We also have plots from the Jug Bay area to analyze and could compare species diversity, abundance and distribution between the Preserve and the Jug Bay area.

This report did not determine the relationship of DBH and abundance, which may provide additional insight into the distribution and associations of different species. Future investigations are needed to determine this relationship

An added benefit was that the study proved effective in training volunteers to identify both the common and uncommon plants. Involving volunteers in data analysis, without needing to become educated on more complicated multivariate analysis, provided and opportunity to answer questions about their field observations using data they collected. Through this exercise, they became more enlightened citizen scientists.

Future Plans

Similar analysis of distribution and abundance of the other plots will document the species diversity at the Preserve. Comparing the Jug Bay area, which has undergone no active management for 20 years to the Preserve may offer insight into forest regeneration and forest associations of the Sanctuary.

Accurate mapping of habitat types will require a more intensive study and finer resolution than our 100 square meter plots located 100 meters apart can provide. Transect studies will be conducted to delineate how the habitats change over the land. Incorporating data into a GIS program would facilitate further analysis of species relationships.

Deer populations, invasive species, and management practices will require distinct studies to determine the specific impacts to our native vegetation.

Acknowledgements

Many volunteers were instrumental in developing this study, and collecting and compiling data.

In addition to conducting the surveys, these volunteers assisted in preparing this report: Cynthia Bravo, Gordon Burton, Mary Burton, Tom Englar, Dave Perry, Lisa Siciliano, Bob Smith, and Sandy Teliak.

These volunteers assisted with the field work: Cassie Bushong, Sandy Curry, Fae Davis, Lynette Fullerton, Carolyn Fulton, David Laughlin, Louise Miles, Dave Mozurkewich, and Nicole Preti. Staff naturalists, Lindsay Funk Hollister and Elaine Friebele, assisted in all aspects of the study.

References

Brown, R. G. and M. L. Brown. 1972. Woody plants of Maryland. Port City Press, Baltimore. 347 pp.

Burke, J, and Swarth, C. 1997. Tree and shrub habitats at Jug Bay Wetlands Sanctuary. Technical Report of the Jug Bay Wetlands Sanctuary. 19 pgs.

Burns, R. M. and B. H. Honkala. 1965, revised: December 1990. Silvics of forest trees of the United States. Agriculture Handbook 654. [online]. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p. Available: http://www.na.fs.fed.us/spfo/pubs/silvics_manual/table_of_contents.htm

Cote, S. D., Rooney, T. P., Tremblay, J. P., Dussault, C. and Waller, D. M. 2004. Ecological Impacts of Deer Overabundance. Ann. Rev. Ecol. Evol. Syst. 35:113147.

Harlow, W. M. 1959. Fruit key and twig key to trees and shrubs. Dover Publications. N.Y. 106 pp.

Kays, J. S. et al. 2003. Resistance of ornamental to deer damage. University of Maryland Cooperative Extension Service, Wildlife Damage Management Fact Sheet 655.

Petrides, G. A. 1986. A field guide to trees and shrubs. Houghton Mifflin Co., Boston. 428 pp.

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

Rooney, T. P. 2001. Impacts of white-tailed deer to forest ecosystems: a North American Perspective. Forestry 74:201-208.

Tiner, R. W., Jr. 1988. Field guide to nontidal wetland identification. Maryland Department of Natural Resources, Annapolis MD and U.S. Fish and Wildlife Service, Newton Corner, MA. Cooperative Publication. 283 pp. + plates.

United States Department of Agriculture Soil Conservation Service (USDA SCS). Soil survey of Anne Arundel County. 1973. [online] Available: http://www.sawgal.umd.edu/nrcsweb/aaconvert/index.htm)

List of Tables

List of Figures

Appendix

A1. Habitat survey protocol

A2. Habitat survey data sheet

B. Table of the 100 largest trees, including plot and DBH

C. List of plots where species were found

D. Summary of species found in each plot

List of Photographs

Photographs by Cynthia Bravo.

1. Tom Englar establishing a plot with Gary Pendleton and a youth volunteer.

2. Fagus grandifolia in 529-N. White PVC grid marker pole can been seen to the right of the larger tree

3. Quercus falcata in 533-Q. Largest tree in the Level Plots. DBH=63.3 cm

4. Second largest tree in the Level Plots—*Acer rubrum* (DBH=61.0 cm) in 531-W.

5. Fagus grandifolia in 535-O, fourth largest tree in the Level Plots (DBH=50.5 cm)

6. Prunus serotina in 525-P, largest black cherry in the Level Plots (DBH=41.0 cm)

7. Plot 534-Q had 30 Pinus virginiana, the only species (of six found in the plot) that had a DBH of >4.0 cm

8. These six Populus grandidentata were the only ones of this species found in the Level Plots (in 539-L).