VIRGINIA TECH

Forest Ecological Assessment
May 2012

VIRGINIA POLYTECHNIC INSTITUE AND STATE UNIVERSITY

Forest Ecological Assessment

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2.0 *INTRODUCTION*

With 140 years of stable land ownership, the campus of Virginia Tech occupies a unique place in the history of Virginia and, indeed, the nation. Located within the ridge and valley physiographic province, the area within and surrounding Blacksburg, Virginia is currently comprised of a mix of urban, suburban, rural, commercial, industrial, agricultural and forested land. At the southern end of campus, located adjacent to Lane Stadium, lies an approximately 13.75 acre patch of old growth forest herein referred to as The Woods (Appendix A). Within its immediate surroundings, The Woods is bordered to the north by the existing student tennis courts, to the south by Southgate Center, to the east by residential development and to the west by Lane Stadium and the outdoor practice facility. In a more regional context, The Woods and Virginia Tech itself, is settled in amongst the agricultural land within the valley between Brush Mountain to the north, Paris and Hightop Mountains to the east and Price Mountain to the south and west Appendix B.

Despite ever-changing land use and historic forest displacement, The Woods has persisted and is perhaps the only remaining functional forested ecosystem within walking distance to the central portion of campus. The Woods is a remnant example of what the forest ecosystem may have been like prior to European settlement. This remnant of an Oak forest system is typical for the region, especially in the more mountainous areas that have had minimal disturbance for an extended period of time. It can be reasonably assumed that the areas surrounding The Woods were stripped of woodland cover in the historic past given the needs of building materials, fuel, crops and pasture. In the absence of these pressures, much of the surrounding land likely would be similar in composition to The Woods.


The Woods North

The current state of The Woods and the primary management approach has been one of minimal effort. An asphalt path runs along the eastern border and another asphalt path bisects the forest into northern and southern segments. A rudimentary, informal trail system exists and is used primarily by the students and town residents as simply a corridor between destinations. There is an existing rappelling tower in the center of The Woods north that is used by the Corps of Cadets, who also use the site for training activities. There is evidence that studies are ongoing at the site as part of a student curriculum. The area around the rappelling tower is maintained free of underbrush and herbaceous plants. Little other active management has occurred, with the exception of this maintenance.

Recognizing the controversial nature of the proposed siting of the new indoor athletic facility (Appendix C) within this forested ecosystem, Virginia Tech contracted Biohabitats, Inc. of Baltimore, MD to conduct an ecological characterization of The Woods and, based on the ecological characteristics of the site, determine the suitability of the site to support development without compromising ecological integrity. This development suitability report is a summary of the work Biohabitats has done and contains:

- applicable pre-existing data,
- data gathered onsite
- site inventory and characterization
- site analysis
- suitability and resource conservation maps.

3.0 *THE WOODS CHARACTERIZATION METHODOLOGY*

Understanding the structural composition of The Woods, along with the ecological processes affecting its continued evolution, is the critical first step in determining ecological value of the site. A baseline assessment provides a benchmark by which to evaluate the potential impacts of forest clearing. While it is difficult to measure directly the ecological status of any ecosystem, measuring the underlying components of the ecosystem is a practical means to characterize its overall health and diversity. By measuring components such as the structure of the vegetation, the presence of a variety of geomorphic features along with the spatial relationship of varying habitats within the study area allows the inference of overall ecological health of an ecosystem. Unfortunately, there are still metrics that can only be looked at from a qualitative standpoint such as the potential for endangered species and the possibility that groundwater recharge is occurring in any given landscape. In addition a metric may be measured quantitatively, however the impact that an activity may have upon that metric from an ecological perspective may only be qualitative. For instance, while you may be able to quantify the amount of forested area removed from a given forest stand, the affects that the removal of that forest has on the wildlife within it can only be measured qualitatively prior to the removal. Throughout this section, Biohabitats has noted if metrics are quantitative or qualitative and if the effects of the proposed activity can be assessed quantitatively or qualitatively (e.g. quantitative metric, qualitative impact assessment).

In order to assess and characterize the current status of the forest in The Woods, Biohabitats Inc. undertook a three-fold assessment strategy. The first step was to utilize the Land Suitability Index, to compare the three potential locations for the indoor practice facility. The second step was to use the i-Tree/UFORE model to assess the benefits of the forest within The Woods from a carbon sequestration and natural capital perspective. The final step was to use forest condition scoring metrics developed in-house as a means of characterizing the ecological structure and diversity of The Woods.

Forest Assessment Efforts

These three steps required the analysis of digital GIS information as well as a stratified random sampling of the vegetation in the woodland. In March 2012 four (4) vegetation plots were sampled within the forest. Plot center locations were recorded using sub-foot level Trimble Geo XH GPS units. Two of the plots consisted of a 1/10 acre diameter tree and understory sample for the i-Tree model, while the other 2 randomly located plots were utilized for the forest condition scoring metrics.

3.1 *Land Suitability Index*

To identify areas that are relatively more suitable for conservation or development, the Land Suitability Index (LSI) process was refined by Biohabitats. The LSI uses landscape ecology principles, a site metric classification system, and GIS to facilitate resource valuation. Since this index is designed as a comparison tool, the metrics were utilized to compare the three potential facility locations within The Woods, the site that lies parallel to Washington Street over the student tennis courts and the site that lies perpendicular to Washington Street over student tennis courts. The site that lies perpendicular to Washington Street over the tennis courts is a third alternative that was investigated after the initial draft version of this report, therefore it shall hereafter be referred to as "the alternative site."

Physical and ecological site attributes identified in the site inventories were organized and in some cases reorganized using accepted ecological principles and best professional judgment. The number of attributes assigned to each of the metrics is not uniform, which is a function of the amount of pertinent available information, accepted ecological principles, and best professional judgment. Ecological Analysis Metric Attribute Maps were produced, when appropriate, under the following metrics:

Streams,
Wetlands,
Groundwater,
Geomorphology,
Vegetation,
Landscape ecology and
Wildlife habitat

The attributes of each metric were then mapped in GIS. A brief discussion of the metric attributes mapping follows.

A. Stream Metric Attributes
- -hydrologic regime (ephemeral intermittent, or perennial), (quantitative metric, qualitative impact assessment)
- -estimated regulatory stream buffers and conservation buffers (100 feet), (quantitative metric, quantitative impact assessment)
- -FEMA 100-year floodplain and the 50 year floodplain (estimated as one third of the 100-year floodplain) (quantitative metric, quantitative impact assessment), and

-stream quality (habitat - high, medium and low, as determined through visual assessments made in the field by Biohabitats) (quantitative metric, qualitative impact assessment).

B. Wetland Metric Attributes hydric soils,
-wetland size (<0.1ac, 0.1-0.33ac, >0.33ac) (quantitative metric, qualitative impact assessment)
-special isolated wetlands such as vernal pools (quantitative metric, qualitative impact assessment), and
-wetland conservation buffers (0-100 and 100-200 foot widths) (quantitative metric, qualitative impact assessment).

C. Groundwater Metric Attributes
-recharge zones- pervious, semi-pervious and impervious soils as measured by saturated hydraulic conductivity (Bear 1972) (qualitative metric, qualitative impact assessment).

D. Geomorphology Metric Attributes
-soil erodability (K factor*) (quantitative metric, qualitative impact assessment), and
-slope (0-15%, 15-25%, and >25%)(quantitative metric, qualitative impact assessment).

*Erosion K factor indicates the susceptibility of a soil to sheet and rill erosion by water. K factor is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

E. Vegetation Metric Attributes
-rare, threatened or endangered species or habitat (qualitative metric, qualitative impact assessment),
-tree age classes (0-50 years, 51-75 years, >75 years) (quantitative metric, qualitative impact assessment), and
-species abundance (low, medium and high) (quantitative metric, qualitative impact assessment).


Erodible Slopes

F. Landscape Ecology Metric Attributes
-habitat corridors (primary, secondary and isolated) (quantitative metric, qualitative impact assessment),

-distance to the nearest adjacent corridor [0-1.5 kilometers (0.93 miles) and >1.5 kilometers (0.93 miles)] (quantitative metric, quantitative impact assessment),
-patch structural integrity (solid->90% forest cover, porous-50-90% forest cover and stepping stone-<50% forest cover) (quantitative metric, quantitative impact assessment).
-total forested patch size (0-24 acres, 25-39 acres, and > 40 acres) (quantitative metric, quantitative impact assessment),
-interior forested patch size (0-24 acres, 25-39 acres, and > 40 acres) (quantitative metric, quantitative impact assessment) and
-distance to the nearest adjacent patch [0-0.5 kilometers (0.31 miles), 0.5 (0.31 miles)-1.5 kilometers (0.93 miles) and >1.5 kilometers (0.93 miles) (quantitative metric, quantitative impact assessment).

G. Wildlife Habitat Metric Attributes
-hardwood stands (<50 years old and >50 years old) (quantitative metric, qualitative impact assessment),
-avian habitat (qualitative metric, qualitative impact assessment), and
-vernal pool (quantitative metric, quantitative impact assessment).

Metric Classification System and Suitability Analysis

A simplified system was developed that grouped similar ecological attributes into Metrics and then classified each attribute so that they could be differentiated and assessed geospatially. The classifications and values associated with them were constructed based on the information synthesized in the metrics, accepted ecological principles, and best professional judgment. The Classifications for attributes are:

Classification 0 – Disturbance will result in no ecological impact*,
Classification 1 – Disturbance will result in marginal ecological impact,
Classification 2 – Disturbance is acceptable if Best Management Practices (BMPs) or restrictions are applied**,
Classification 3 – Disturbance will compromise ecological integrity,
Classification +1 – Regulatory restrictions or conservation areas are present.

*Disturbance is defined as those activities related to construction, development, and operations and maintenance of the site. It does not include activities such as forest management activities that are used to improve ecological integrity.

**BMPs refer to structural and non-structural practices that are applied in these areas to protect existing ecological resources and processes. These BMPs go beyond the standard level of practice BMPs that may be associated with typical construction and development activities in areas of the site. Examples might include redundancy of erosion and sediment control practices, expanded tree protection zones, use of trenchless technologies, reforestation etc.

The metric data sheets and Classification Table is included in Appendix D. In this system, attributes in Classifications 0-3 may also occur where regulatory restrictions apply or where conservation areas have been proposed or identified. In those cases, the Classification +1 is also applied to the attribute. The result for each attribute is a Land Suitability Index (LSI), which is a value that is assigned to that particular attribute in the GIS analysis. In the case where attributes are assigned a Classification between 0 and 3 and also assigned a Classification of +1, the Land Suitability Index is increased by one unit. The range of Land Suitability Index values in the Metrics Table is therefore 0-4. As an example, an attribute with a Classification of 3 and a Classification of +1 has a resultant LSI of 4.

The maps associated with the combined Metric Suitability Analysis are included in Appendices E-J. It is important to remember that the ranges of sensitivity shown on each map are only with respect to the metric being analyzed. The full implication of the Metric Suitability Analysis is ultimately realized when all the metrics are combined, as is described and presented in the following section.

Overlay of Land Suitability Index Values Composite Map

Using GIS, all the Land Suitability Index values for all the attributes in all the metrics were brought together, by overlaying and collapsing on a single map. The Land Suitability Index values for all the respective Metrics were then compiled onto a composite map which can be found in Appendix K.

3.2 *i-TREE*

In accordance with the sampling protocols of the US Forest Service (USFS) i-Tree model, Biohabitats laid out two (2) stratified random sample plots to measure the carbon sequestration and air pollutant interception value associated with The Woods. Forest data recorded within these $^{1}/_{10}$ acre plots included species, size, canopy height, height to base of live canopy, dieback percentage, crown light exposure, and percent canopy missing. Information recorded was submitted to the USFS for analysis using the i-TREE model. Understory parameters included species presence, percent herbaceous ground cover, percent downed woody debris and percent invasive plant cover. Comments and observations were also recorded for unusual specimens, active insect or disease activity, and general forest conditions. The i-Tree model also provides the ability to analyze the sites for the potential of infestation by insect pests and the affect that these pest may have on the existing forest. The i-Tree model uses measured quantitative information from the site, and based upon empirical data derived from studies of carbon sequestration, storage, etc., makes quantitative assumptions regarding the forest/trees being evaluated for their efficacy and value from a structural standpoint.

3.3 *Forest Condition Scoring*

Forested stands were initially delineated using color aerial photos. Further field investigation with GIS drawings containing topography, streams, and soils allowed for more defined separation of the forested areas into specific forest communities. Using 1/10th acre fixed radius circular plots, the species and size composition was determined for tree, shrub and groundcover layers in each stand.

A set of parameters was developed for scoring the relative quality of the forest condition as it relates to the functional ability to provide ecosystem services. These parameters were given a range of values from 0 to 5 (5 being the highest value or most beneficial) for positive attributes (e.g. Number of species, number of strata, and proximity to critical areas). Negative attributes (e.g. Presence of invasives and disease) were assigned negative values ranging from -1 to -5 (-5 being the worst condition). The possible range of scores for this analysis is -8 to 67 points. The information gathered during field data collection efforts is quantitative in nature and due to the fact that there is no assessment of impacts associated with the Forest Condition Scoring, it can be deemed neither quantitative nor qualitative.

Using a data dictionary developed in Trimble Pathfinder software, data was collected for each stand using a Trimble Geo XH GPS handheld datalogger. The cumulative scores of these parameters were calculated and each stand was ranked, based on its cumulative score, within the -8 to 67 point range.

Large Oak Tree in The Woods North.

Forest Stand Quality Parameters:

- Number of Species: Cumulative number of native species in all layers.
- Seral Stage (age class): Successional stage of forested area.
- Vertical Structural Diversity: Number and extent of vegetative layers (i.e. Canopy, understory, herbaceous/groundcover).
- Natural Regeneration Potential: Native seedlings present or not.
- Forest Interior: Forest interior within the stand.
- Non Native Invasive Species: Percent of NNIS present in each vegetative layer.

Specimen Trees/Significant Trees: Trees >24" DBH present or not.
Disease/Infestation: Significant disease or insect infestation present or not.
Proximity to other forested areas/types (corridor potential)
Proximity to other natural features of importance (water, floodplains, hydric soils, erodible soils)

The results of the forest condition metrics and scoring can be found in Appendix M and Appendix N, respectively.

3.4 *The Woods Site Observations*

The Woods is approximately 13.75 acres in size, as measured by the canopy extent of the overstory trees. Based upon current maintenance practices, there are portions of the understory that are maintained as manicured lawn and pedestrian trails. This maintenance and presence of trails reduces or eliminates many of the forest ecosystem functions and processes and therefore one can argue that the extent of the forest should be the extent of the areas where these ecosystem functions and processes no longer exist. This area has been calculated to be approximately 11.79 acres. As such, we have created two maps of the forest, one with the canopy extent as the forested area and one with the understory extent as the forested area. Both of these maps may be found in Appendix A. For the purposes of this report the metrics were calculated based upon the forested site being the 13.75 acre area. This is done because the i-Tree model looks primarily at the overstory trees, whereas the other methodologies are more qualitative and are less influenced by the presence of the trails and maintenance practices. Pre-sampling reconnaissance of the forest, along with analysis of the sampling results, indicates that there are two different vegetation stands within The Woods. The asphalt path that bisects the forest creates a substantial break in the understory which warrants the designation of The Woods north and south. Overall the stands are of similar species composition, age class and density. However The Woods north has a higher component of invasive species. The presence of invasive species such as privet (*Ligustrum sp.*) is likely due to the greater amount of forest edge along the southern and western exposures. This forest edge has experienced relatively more disturbance, allowing additional sunlight to enter the understory, which promotes invasive species establishment and persistence. The presence of Lane Stadium itself cast a significant shadow over the western edge of The Woods south that helps preclude the presence of invasive species. It should be recognized that both The Woods north and south are complex mosaics of changing vegetation and that stand boundaries and delineations do not represent clear, on-the-ground transitions. For instance the maintenance performed around the rappelling tower and mowing that occurs along the asphalt path corridors creates a variety of habitat types within the forests themselves. Community types contain variability within the stand and the boundaries shown are intended to demonstrate that there are tangible differences between these units that can impact management decisions.
Forest Stand Descriptions

The Woods North – The northern portion of forest [approximately six (6) acres] is located adjacent to the outdoor football practice facility and the tennis courts. The forest canopy is dominated by numerous large white oaks (*Quercus alba*). There are several large black oaks (*Quercus velutina*) as well in the overstory while the midstory is dominated by sweet cherry (*Prunus avium*) and black cherry (*Prunus serotina*). Significant invasive plant presence was detected in the understory and the herbaceous layer was dominated by exotic invasive species such as Japanese honeysuckle (*Lonicera japonica*) at the time of field data collection. This stand has a high level of canopy closure and has a minimal understory layer with the exception of the invasive species.

The Woods South – The southern forest (approximately 7.75 acres) is of similar structure in that it is dominated primarily by white oak and black oak with sweet and black cherry being the dominant midstory tree species. There is a high level of canopy closure and a well established and dense understory layer. Low levels of invasive plant species were noted in part due to the shading that Lane Stadium provides. As with the northern forest stand, the herbaceous layer was dominated by exotic invasive species such as honeysuckle.

Trails and Large Oak in The Woods South.

Patch Disturbance

Although the relatively long life spans of tree species tend to convey a sense of permanence to the landscape, forest systems are not static, monolithic entities. Successional change in response to stressors and the differing regeneration requirements of various species gradually modifies the forest composition over time. In The Woods this is evidenced by the lack of American chestnut (*Castanea dentata*) and in the fact that exotic invasive species have begun to dominate the understory. American chestnut was likely a dominant or codominant species within The Woods until the appearance of the chestnut blight (*Cryphonectria parasitica*) in the early twentieth century which has brought this species to the brink of extinction within its native range.

The dominance of invasive species within The Woods can preclude the natural regeneration of the dominant oak species and therefore alter the future characteristics of The Woods. In The

Woods south, where the invasive species understory is limited, this conversion may proceed at a limited pace, while a different story unfolds in The Woods north where the invasive component is much higher.

Catastrophic wind events that result in partial canopy failure allow additional light penetration onto the forest floor. The increase in light levels in these patch disturbances can drive regeneration in two primary directions within The Woods. In The Woods south, with a less dense population of invasive species, a desirable mix of hardwood tree species is likely to be encouraged to fill any canopy gaps. In The Woods north, the additional light falls upon a waiting mix of invasive vine species which rapidly colonize the disturbance area. In the space of one or two seasons, species such as Japanese Honeysuckle can create an impenetrable tangle of foliage that quickly degrades the ecological integrity of the site and arrests desirable tree replacement for decades.

The isolated nature of The Woods, an island of woodland surrounded by extensive urbanization, creates a high degree of vulnerability to wind-related tree failure. It is important to recognize that wind-related tree failure is not, in itself, an undesirable event within the woodland. Disturbance is an important driver of habitat diversification and niche creation. The arrival of woody debris and logs upon the forest floor is part of biogeochemical nutrient cycling and adds structural diversity that can serve as wildlife refuges and nesting habitat.

Invasive Plants

Although The Woods is dominated by a complex of native tree species, there are a handful of exotic invasive plants in the understory that threaten to disrupt the long term health and viability of the woodland. In order to address this threat it is important to understand what “invasives” are and why they present a problem.

According to the National Invasive Species Council, an “invasive species” is:

“…an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health.”

Conservation biologists rate the intrusion of invasive species as the second greatest threat to biodiversity following habitat destruction. Recent economic analyses of the problem have estimated the damage caused by these non-native organisms in the United States to be as high as $120 billion per year.

Invasives tend to be early-successional, high reproductive rate strategists that are adapted to colonize disturbed systems. As non-natives, they may lack many of the constraining factors that held their populations in check in the original ecosystems in which they evolved. Their explosive populations can result in a number of damaging ecosystem disruptions such as:

- Habitat loss
- Reduction in quantity and quality of food sources and nesting sites
- Altered community succession
- Changes in fire and hydrologic regimes
- Altered soil microbiology and decomposition processes
- Disrupted plant-animal and host-plant relationships

As previously discussed, in The Woods there are a handful of plant species that, in combination with site disturbance, have the potential to undermine desirable tree regeneration. Left unchecked, these populations will eventually create an environment at this site that does not support the type of vision expressed by the campus stakeholders.

During the characterization work, the following species were found to be of primary concern with regard to their current level of infestation and potential for future damage:

- Japanese Honeysuckle (*Lonicera japonica*)
- English Ivy (*Hedera helix*)
- Multi-flora Rose (*Rosa multiflora*)
- Bush Honeysuckle (*Lonicera maackii*)
- Japanese Privet (*Ligustrum sp.*)
- Oriental Bittersweet (*Celastrus orbiculatus*)
- Burning bush (*Euonymus alatus*)
- Japanese barberry (*Berberis thunbergii*)

Large Patch of Invasive Species within The Woods North.

It should also be noted that while there is an inherent risk in introducing non-native organisms into an ecosystem, not all exotics display invasive traits. Conversely, there are also native species that can display aggressive growth habits and adversely impact desired forest benefits.

If a forest management plan was to be considered for The Woods, control of invasive exotics will require a systematic, yet flexible, adaptive management approach. It is critical that an ecosystem-based approach be utilized in suppressing invasive plant activity, as a “see-and-spray” weed-killing mentality is likely to yield poor results and non-target plant mortality. It is also advised that areas of treatment be prioritized and phased as treating the entire site in one application could cause a dramatic negative visual impact.

Habitat Quality

While the vegetation characterization of The Woods did not include direct, quantitative measures of habitat suitability for any particular animal species, general qualitative observations were made. In addition, several inferences and recommendations can be made based upon the relative richness of plant species, structural composition of the forest stands and spatial configuration of the site.

General habitat requirements for woodland fauna that might call The Woods home include four basic elements: food, cover, space and water. Planning for these needs can enhance the attractiveness of this woodland for desirable species. In The Woods, for instance, there are native dogwoods (*Cornus florida*) that can provide an important energy source for cedar waxwings. Immediately adjacent to The Woods, and to a small degree within, are coniferous White pines (*Pinus strobus*) that create thermal cover for overwintering wildlife. What The Woods lacks is space and the current capability of being linked to other intact wildlife corridors. The adjacency of nearby forest patches and corridors does however make The Woods a 'stepping stone' forest that allows wildlife the opportunity to forage from and to this isolated forest. The Woods and numerous other forest patches and corridors can be seen on the map in Appendix B.

Adjacent corridors such as Brush Mountain, Price Mountain, and Paris and Hightop Mountain, which are all part of the larger Appalachian Mountain corridor, provide migration routes for numerous animals. It is important to note that migration is not solely plants and animals moving long distances, such as the migration of neotropical birds between South America and North America. For example, migration can be as simple as a juvenile box turtle that is departing the home range where it hatched to establish a new home range for itself. In this instance, the migration may be limited to a few hundred yards. Migrating birds and mammals that use these corridors can carry seeds that increase the distribution of plant species throughout the area. Just as these plant and animal species migrate along the corridors, they also migrate between the corridors. Many of them accomplish this via patch habitats. These habitats can be stepping stones between corridors and are stop over points between destinations. Without further investigation into the existing flora and fauna present within The Woods, and within each adjacent corridor and patch, determining which species may use The Woods as a stepping stone could prove to be very difficult. The list of species could number in the thousands and without thorough year round studies the full extent may never be known. The greater the distance between patches and corridors, along with the degree of development between them, makes it less likely that the patches would be utilized for migration purposes. If for instance two patches were more than a mile away but were only separated by farm fields, it is more likely to be used by some species as a migration corridor than two patches that are 0.5 miles apart separated by a heavily urbanized area. The patch habitats shown in Appendix B were identified based upon a size of greater than approximately 20 acres as well as the potential presence of understory, potential forest interior (forest width exceeding 600') and proximity to corridors and other patches. These patches may have varying degrees of importance for various flora and fauna and their spatial location and the land use between them may make some patches of higher value for migratory species.

This relative isolation has conversely also worked to the advantage of The Woods. It has reduced the impact of white-tailed deer (*Odocoileus virginianus*), a potentially destructive herbivore. Excessive deer densities are an epidemic problem throughout urban and suburban areas of the east coast and can have a large negative impact on native plant populations. During the vegetation assessment no indication of browse damage, or deer presence for that matter, was evident.

Standing dead trees and downed deadwood are components of the forest structure provide the potential habitat for cavity nesting avian and mammalian species and invertebrates. The presence of standing snags and downed deadwood provides structural elements as refuge sites and nurse logs.

The absence of any permanent water feature within The Woods limits the habitat quality of the woodland for certain species. Although more mobile species could access water via the pond adjacent to the Veterinary Medicine complex or the duck pond, lack of a reliable water source limits the habitat potential of The Woods for some species.

The dominant oak species within The Woods generate large quantities of mast that significantly increase the food potential of the woodland for wildlife, and make this area important for wildlife, despite the lack of a dependable water source. Table #1 contains additional wildlife resource information.

Table #1 Examples Wildlife Food Value – The Woods Species (Martin 1951)

Species	Example Potential Wildlife Species	Potential Number of Species Using Plant	Seasons of Availability
Cherry	cedar waxwing, raccoon, red squirrel, white-footed mouse	56	Spring, fall
Dogwood	bluebird, cardinal, cedar waxwing, rabbit	47	Spring, fall, winter
Oak	blue jay,woodpecker, turkey,chickadee, crow,	43	Spring, fall, winter

	raccoon, deer, squirrel, rabbit, mouse, chipmunk		
Pine	chickadee, brown creeper, gray squirrel, mourning dove, nuthatches	33	Winter
Poison Ivy	chickadee, gray catbird	28	Fall, winter
Maple	chipmunk, squirrels, deer	27	Spring, summer, fall
Greenbriar	catbird, mockingbird, raccoon	23	Fall, winter
Virginia Creeper	Bluebird, crow, flicker, flycatcher, mockingbird, chickadee, nuthatch, robin, thrush Titmouse, vireo Woodpecker, rabbit	30	Fall, winter

Forest Health

Visual analysis of the tree canopy and understory within the sample plots revealed no visible evidence of any major insect or disease activity. Given the proportion of oaks in the overstory and white ash in the midstory, particular attention was paid to detecting potentially catastrophic insect pests – the Emerald Ash Borer *(Agrilus planipennis)*, Asian Longhorned Beetle (*Anoplophora glabripennis*) and Gypsy Moth (*Lymantria dispar*). Additional information on these species can be found in the i-Tree report in Appendix L.

Specimen Plants – Unique Site Features

The forest canopy within The Woods is fairly heterogeneous in age class and can be considered as "old-growth." This term is used to describe a forest system that has been allowed to establish and grow without major disturbances over a long period of time. Typical of most old-growth forests, The Woods has a diverse structure in which there may be many age classes of trees which form canopy, midstory and understory layers. This diversity in age structure also promotes a diversity of habitat and wildlife which therefore leads to greater ecosystem function. The majority of the canopy layer is made up of large white oak trees with a smaller, younger black oak component. The approximate age of a tree can be determined by measuring the diameter of the tree and multiplying the diameter in inches by a growth factor specific to the species of tree one is measuring. The growth factor for a white oak is five (5), and while there is no specific growth factor for a black oak, the growth factor of the red oak, four (4), is utilized for this exercise since they are both in the red oak family. By using growth factors it can be determined that there is a broad distribution in the age class of white oaks within The Woods. The white oak trees vary in age from young saplings, to the largest white oak that is approximately 285 years old. Based upon the oak growth factor, there are 32 trees within The

Woods that are greater than 200 years old. A broad age distribution can be seen among the black oaks as well from saplings to the largest black oak which is approximately 164 years old. Twenty-eight black oak trees are approximately 100 years in age or older. In all there are 113 oak trees within The Woods that were likely present when the university was founded in 1872 based upon these oak growth factors. A map of the trees over 20 inches in diameter at breast height, as recorded by the New River Valley Master Naturalists, can be found in Appendix O (J.R. Seiler, personal communication, February 15, 2012). The location, species and diameter of this inventory was spot checked during field data collection efforts.

Another method of tree age estimation includes increment borings, where a sample core is taken from the tree to count the number of growth rings. Increment boring can be a way to calibrate/validate the oak growth factor for a given forest since the antecedent conditions over the lifespan of forest can vary from location to location. The Woods may have experienced long term drought or long periods of desirable growth that can skew the growth factor in either direction. An increment boring was performed by the Department of Forest Resources and Environmental Conservation on a 40” white oak tree within The Woods north. This boring indicated that the available core was 238 years in age. The center of the tree was not reached due to the fact that rot was encountered, however it was estimated that an additional six (6) inches of tree was remaining which would bring the total tree age to 346 years (J.R. Seiler, personal communication, February 15, 2012). This increment boring indicates that a tree estimated to be 200 years of age based upon growth factors in The Woods may in fact be nearly 350 years in age. Based upon this calibration of the growth factor for oak trees (approximately 8.65) within The Woods as many as 59 white oaks within this forest may in fact be approximately 300 years in age or older.

4.0 *SITE ASSESSMENT RESULTS*

4.1 *Land Suitability Index*

The LSI measurements were developed as methodology to identify areas within a site that have ecological importance and also facilitate ranking of importance. Conversely, this methodology also identifies areas more suited for development. Using LSI measurements, proposed facility locations within The Woods and the tennis courts can be directly compared. The results of the LSI metrics as they relate to both The Woods north and south are as follows:

Tennis Court Site.

Stream Metric Attributes

The Woods Site.

Due to the lack of streams and ephemeral channels as defined by the United States Army Corps of Engineers (USACE) at all three sites, this metric was only partially analyzed. The flow path that divides The Woods into northern and southern sections has the potential to be an ephemeral channel and may potentially be a hindrance to the development of the indoor facility therefore a score of 1 was given to The Woods. The lack of stream channels precludes the presence of regulatory buffers, floodplains and aquatic habitat as well; therefore, the remaining metrics for all three sites were given no score.

Wetland Metric Attributes

Alternative Site.

Due to the lack of wetlands as defined by the United State Army Corps of Engineers (USACE) and Virginia Department of Environmental Quality (VADEQ) at both sites, this metric was only analyzed for the presence of hydric soils which have the potential to support wetlands and increase the number of available habitats. The soils located within the proposed facility locations consist solely of the Groseclose-Urban land complex and Urban land. Both soil types are listed as containing 3% hydric soils within stream terraces and depressions, neither of which occurs at either site and therefore, no points were assigned to either site for this metric.

Groundwater Metric Attributes

Saturated hydraulic conductivity (Ks) is an indicator of the speed at which precipitation can move through the soil column to recharge the local groundwater table. The Ks values of the soils for all three sites range from 0.42 to 1.4 micro m/sec which is classified as semi-pervious. However, when assigning a scoring factor to the two sites, it was determined that since the tennis courts themselves are impervious and only minor disturbance to the current runoff regime would occur, a score of 0 was assigned to the tennis court site, while a score of 1 was assigned to The Woods site and the alternative site due to the extent of lawn and forest that would be impacted by the alternative site.

Geomorphology Metric Attributes

Erosion K factor indicates the susceptibility of a soil to sheet and rill erosion by water. K factor is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water. The K factor for the soils at both sites is 0.24 which is relatively low; therefore both sites received a score of 0 for erodibility.

Steep slopes exist adjacent to all three sites. The slope adjacent to the tennis courts and alternative site would be minimally affected and therefore received a score of 1. The steep slopes at the western edge of The Woods received a score of 0 due to the fact that the slopes would be mitigated by the construction of the facility assuming that a retaining wall is proposed along the northern and eastern facades of the facility at this location.

Vegetation Metric Attributes

The potential for rare, threatened and endangered (RT&E) plant species was determined through cursory consultation with the United States Fish and Wildlife Service (FWS) and the Virginia Department of Conservation and Recreation, Natural Heritage Program (DCR). A complete list of potential RT&E species for Montgomery County from FWS and DCR can be found in Appendices P and Q, respectively. The results of this consultation indicate that numerous RT&E plant species have the potential to occur within Montgomery County and within The Woods. This resulted in a score of 2 for The Woods site and the alternative site. The lack of vegetation and maintenance program associated with the area adjacent to the tennis courts resulted in a score of 0.

One of the vegetation metrics is related to the availability of habitat for RT&E species such as mammals and insects. The results of the consultation indicate that several species have the potential to inhabit The Woods. In particular, the Indiana bat (*Myotis sodalis*) who is known to associate with large white oaks and in particular, ones with some exposure to sun as can be found at the proposed The Woods Site (Callahan, 1997). Other species identified are the Virginia Big-Eared bat (*Corynorhinus townsendii virginianus*), the sedge wren (*Cistothorus platensis*), numerous butterflies and other various species that can be found in Appendix Q. The habitats of the species identified are not likely to exist at the tennis court site which was given a score of 0 while The Woods site and the alternative site was given a score of 3 due to the potential for the presence of the Indiana bat.

Tree age class was evaluated to determine the impact that the proposed facility would have on the trees of differing age classes. The presence of many large specimen oak trees within the Woods and alternative sites warranted a score of 3 for both the >75 yrs and scores of 3 and 2, respectively, for the 51-75yrs age classes. The ability to better mitigate for losses of trees <50 yrs of age was the driving factor in scoring this metric as a 2 for both The Woods and alternative sites. The tennis court site was given a score of 2 for both the <50 yrs and the 51-75 yrs age classes due to the potential to shift the footprint of the building in order to preserve the evergreen trees near Washington Street. No score was provided for the >75 yrs class at this site due to the age of the adjacent trees.

Species abundance was measured to gauge the level of diversity among the species within the sites. The Woods site and alternative sites species abundance ranked high and scored a 2 while the low species abundance adjacent to the tennis courts received a score of 1. If however the potential location of the facility at the tennis courts were shifted to the south slightly to avoid the removal of the evergreen trees, this score may be reduced to 0.

Landscape Ecology Metric Attributes

Neither The Woods, the alternative, nor the tennis court site themselves are a part of a habitat corridor and therefore all three sites scored a 0 for potential impact from disturbance. Similarly, all three sites are not within 1.5 kilometers (0.93 miles) of an adjacent corridor and therefore they scored 0 for this metric as well.

The Woods has greater than 90% forest cover, and received a patch structural integrity score of 2. The tennis court area lacks forest cover, resulting in a score of 0. The alternative site is both a mix of open and forested areas and therefore was given a score of 2 for the disturbance associated with a forest with less than 50% forest cover. While consideration was given to The Woods site receiving a score of 3, it was determined that the siting of the proposed facility, depending upon the height of the facility, has the potential to prevent sunlight from penetrating the forest floor which may reduce the proportion of invasive species within the adjacent portion of The Woods.

The forested patch size of The Woods is less than 13.75 acres and the proposed disturbance of three (3) acres would affect nearly 22% of the existing forest and therefore a score of three was given to this metric. In a larger forested patch, three acres would have less of an affect and would warrant a lower score. The disturbance to The Woods at the alternative location, albeit minimal, still results in the reduction of the forest patch and the loss of significant canopy trees and therefore was given a score of 2. The lack of forest at the tennis court site led to the resulting score of 0 for this metric. Based upon the length and width of The Woods, no portion qualified as forest interior habitat and therefore received a score of 0 for this metric as did the tennis court and alternative sites with their lack of forest. The proximity to the nearest patch for all sites is greater than 1.5 kilometers (0.93 miles) and therefore all three sites received a score of 0.

Wildlife Habitat Metric Attributes

The tennis court site does not contain trees that are greater than 50 years old and therefore this metric received a score of 0. The presence of evergreen trees that are under 50 years old would provide overwintering habitat value for bird and other species, and as a result a score of 2 was given to this metric for the tennis court site. The presence of multiple age classes of trees ranging from less than 50 to greater than 50 years in age within The Woods and alternative sites, and the potential for a 20% loss of forest cover in The Woods led to the score of 3 being given to both age class metrics at both locations.

The potential bird habitat metric scored a 1 for the tennis court site, 2 for the alternative site and a 3 for The Woods site due to the presence of neotropical migrants and other species already known to inhabit the forest. A list of these species can be found in Appendix R.

Vernal pool habitat was not present at any of the three sites and therefore all received scores of 0 for this metric.

4.2 *i-Tree Model*

In order to more fully understand the environmental impact that The Woods has upon the local and regional ecosystem, a forest benefit and value appraisal was undertaken using the US Forest Service Urban Forestry Effects i-Tree Ecosystem model (i-Tree). I-Tree is a peer-reviewed model designed to assist land managers and researchers in quantifying urban forest ecosystem structure and function. The model has several parameters to which it applies value, two of which were used in The Woods characterization. The parameters used in appraising the ecosystem benefits at The Woods were:

Carbon Storage & Sequestration (total carbon stored and net carbon sequestered annually)

Air Pollutant Interception (hourly pollution removal of ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide, and particulate matter less than 10 microns in size).

Potential Pest Impacts

In accordance with the sampling protocols of the US Forest Service Urban Forestry Effects Model (UFORE), Biohabitats laid out two (2) random sample plots to measure the carbon sequestration and air pollutant interception value associated with The Woods. Plot centers were recorded using sub-foot level Trimble Geo XH GPS units. Tree cover within these $^{1}/_{10}$ acre plots was measured as to species, size, canopy height, height to base of live canopy, dieback percentage, crown light exposure, and percent canopy missing. Information recorded was submitted to the USFS for analysis using the UFORE i-Tree Ecosystem Analysis model.

Gross Carbon Storage

The carbon component of i-Tree was utilized to estimate both the total carbon stored and the annual amount of carbon sequestered by The Woods forest tree population. Current carbon storage was computed based upon the biomass of the sampled trees. Biomass was calculated for each plant using allometric tree volume equations from classical forestry literature. When more than one equation exists for a species, the mean of the results from the various equations is used. When no species specific information is available for a specific diameter class or height, values representative for the appropriate genera are substituted. If no genera specific equations exist, the average result for either conifers or hardwoods of that size are utilized as a proxy. Estimation of the biomass of large trees (> 38 inches dbh) is done through the use of volumetric equations drawn from the literature along with the specific gravity of wood.

The i-Tree model estimates gross carbon sequestered, per year, in trees by combining average growth projections for forest trees in the appropriate genera and diameter class with adjustments for tree condition (dieback). Average height growth is estimated based upon formulas from the literature and the specific diameter growth factor applied to that tree.

Condition class information is used to adjust the predicted growth rate. Trees with 0-25% dieback are multiplied by 1; in effect, no change is made to the growth prediction. On plants with greater than 25% dieback, growth rates are adjusted downward. The growth rate of dead trees is multiplied by zero as annual carbon sequestration has ceased for these plants. The final annual sequestration amount is determined by subtracting the current carbon storage (year x) from the carbon storage predicted in trees of the size estimated for year x+1.

Economic Value Carbon Sequestration

In order to estimate the economic benefit associated with the sequestration of carbon by the trees at The Woods, the model utilized by Nowak and Crane (2002) to estimate the total monetary value of urban trees in the coterminous USA was applied. In their analysis, the carbon values for storage and annual sequestration were multiplied by $22.8/tC based upon the marginal social costs of atmospheric carbon dioxide.

Maintained understory and paths.

The analysis of carbon sequestration at The Woods indicates that this woodland is currently storing 608tC and annually sequestering an additional 21tC/year. Using the estimated marginal social cost figure mentioned above, this translates into a storage value of approximately $11,200 and an annual sequestration value of roughly $389 per year. As a point of regional comparison, UFORE modeling of the City of Washington D.C. (Nowak & Crane, 2002) estimated that the total urban forest carbon storage in that municipality as 523,000 tC with an annual sequestration rate of 16,148tC/yr.

Air Pollution Effects Calculations

Urban vegetation removes a number of air pollutants including nitrogen dioxide, sulfur dioxide, carbon monoxide, ozone, and particulate matter. Gaseous pollutants (e.g., ozone) tend to be removed within the stomata of the leaves, while particles are mostly captured on the plant surface. Hourly air pollution removal by the urban forest and the associated improvements in air quality are calculated using a hybrid multi-layer/big-leaf modeling approach. UFORE uses local hourly weather and air pollution concentration data along with leaf area data to estimate hourly pollution removal of ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide, and particulate matter less than 10 microns in size ("PM_{10}").

Boundary layer height measurements are also used to help estimate percent air quality improvement due to pollution removal by trees. In addition, i-Tree also calculates hourly volatile organic compound (VOC) emissions by trees. VOCs can contribute to ozone formation, and are important to help understand the net effect of trees on ozone and to provide inputs into ozone photochemical models in order to determine the best strategies to improve air quality.

The i-Tree air pollution analysis at The Woods was run using regional meteorological data from the Blacksburg weather station. Based on this analysis, it was estimated that The Woods removes approximately one (1) ton of pollutants per year, which equates to an annual benefit of $5,190.

This information can be further broken down and the loss of function and value associated with the proposed indoor practice facility can be quantified. Assuming a construction footprint of approximately three (3) acres and a total forest site for the entirety of The Woods of 13.75 acres, one can assume a 21.8% reduction in benefits from the loss of forest associated with the facility located within The Woods site. This translates to annual carbon storage of only 475tC and a sequestration rate of 16.4tC annually. Additionally, the reduction in pollutants removed is reduced to 0.78 tons of pollutants removed annually with a benefit of $4,058.

In addition to the benefits of The Woods for carbon cycling and air pollution removal, the i-Tree model also quantifies the total monetary value of the forest structure itself. This analysis provides the total dollar value that would be required to replace the value and function of the forest structure. In the case of The Woods, the entire forest structure value is placed at $5.31 million, and the value of that portion of forest located within the proposed The Woods site construction footprint of $1.16 million.

The placement of the facility at the alternative site would result in a loss of approximately 0.8 acres which would result in an approximately 6% reduction in ecosystem services as measured in the i-Tree model. This would be a loss of carbon storage of 36tC ($311) annually, a loss of carbon sequestration of 1.3tC ($23) annually, a loss of 0.06 tons of air pollutant removal annually, and a loss of $318,600 in forest structure value. The results of the i-Tree model took only those trees within The Woods into consideration. Additional losses due to the removal of the evergreens and street trees between the student tennis courts and Washington Street were not included due to the fact that further field investigation would have been required.

Potential Pest Impacts

The i-Tree results also indicate that insect pests pose a potential threat to The Woods. The Asian longhorned beetle could cause the loss of $893,000 to the forest structure value, while the emerald ash borer has the potential to destroy $74,700 of structural value to the forest. The most significant threat to The Woods however is the potential for gypsy moth infestation, which may cause the loss of $4.31 million in structural value of The Woods. Unlike the Asian longhorned beetle and the emerald ash borer, the gypsy moth is already present within the area. While some oak trees may be able to recover from the defoliation that is caused by the gypsy moth, many may not be able to. This has the potential to have severe and lasting effects on the character and ecological function of The Woods.

4.3 *Forest Condition Scoring*

The results of the forest condition scoring metrics can be found in Appendices M&N. The metric scores as they relate to both The Woods north and south are as follows:

Number of Species (range 1-5): At both sample locations between 5 and 10 trees species were noted giving both forest stands a median score of 3. While the diversity would ideally be higher, in an old growth forest it is expected to see a lower diversity of tree species due to the age of the forest. The amount of diversity displayed in The Woods is relatively high for an old growth forest.

Seral Stage (range 1-5): Both The Woods north and south are considered old growth forests, scoring a maximum of 5 for both

Typical Canopy Structure within The Woods.

sites. Old growth forests with a diverse age structure provide beneficial habitat and ecosystems services.

Vertical Structural Diversity (canopy, understory, herbaceous cover-range 1-5): Canopy cover in both forest stands was greater than 90% and therefore both stands were assigned values of 5. The canopy closure within both forests allows native species to outcompete exotic invasive species that prefer larger amounts of sunlight. The understory within The Woods north was diminished due to the maintenance performed around the rappelling tower and therefore it was given a score of 3 while The Woods south was given the maximum score of 5. The lack of understory species within The Woods north limits the available habitat and diminishes the ecosystem services that can be provided by this portion of forest. Herbaceous cover in The Woods north received the median score of 3 while The Woods south received the minimum score of 1. The presence of additional herbaceous species within The Woods north is potentially due to the additional sunlight that is able to penetrate to the forest floor along the western edge of the forest. Lane Stadium itself blocks available sunlight to the southern forest. This observation supports the findings of the presence of higher numbers of invasive species in The Woods north.

Natural Regeneration Potential (range 0-5): Both forest stands have a score of 5 indicating that a substantial amount natural regeneration is taking place. This is quite possibly due to the lack of herbivores within the forests. Natural regeneration is vital to the longevity and overall health of a forested ecosystem. The presence of regeneration indicates that The Woods would continue to persist as an oak forest ecosystem for future generations.
Forest Interior (range 0-5): Interior forest is typically denoted as the presence of forested area that is a minimum of 300 feet from the forest edge. Being only approximately 460' at its widest margin, The Woods does not qualify as containing interior forest and therefore both the north and south forests received the minimum score of 0 for the presence of interior forest. Due to the lack of this habitat, it is assumed that the diversity of avian fauna within The Woods is diminished as compared to a forest with interior habitat.

Non Native Invasive Species (canopy, understory, herbaceous cover-range -1 to -5): The invasive species component of the canopy layer within both forest stands received the best possible score of -1. This is due to the dominance of native species in both stands and reduces the chance that someday The Woods would become a monoculture of a single invasive species of canopy tree. The diversity that this affords improves the ecological function of The Woods. Invasive species in the understory were prevalent in The Woods north which received the worst possible score of -5, while their abundance in the southern stand resulted in the median score of -3. The presence of invasive species within the herbaceous layer yielded similar results. The Woods north again received the worst possible score of -5 while The Woods south received the best possible score of -1. The reason for the presence of invasive species in the understory and herbaceous layer species are likely the same as for the overall diversity in these layers. The additional sunlight penetrating to the forest floor from the west allows a greater number of invasive species to establish within The Woods north.

Specimen Trees/Significant Trees (range 1-5): Again, both stands have a score of 5 due to the high number of specimen trees that are present. The specimen trees in both stands allow for a greater amount of habitat and will generally improve ecosystem processes within a forest stand.

Disease/Infestation (range 0 to -5): The presence of disease and infestation was not readily visible during field efforts and therefore both forest stands were given a score of 5. There is the potential that the emerald ash borer may eventually inhabit The Woods due to the presence of white ash within the understory.

Proximity to other forested areas/types (range 1-5): The ranking for proximity to other forests was given a score of 1 for both forest stands. This is indicative of the isolated "patch" nature of The Woods. While one could argue the presence of the stands to one another, one could also argue that fact that The Woods could be viewed as one forest and not divided into northern and southern stands.

Proximity to other natural features of importance (forest, water, RT&E species, erosive soils, hydric soils, floodplain-range 1-5): The ranking for proximity to wetland, rare threatened and endangered species, erosive soils, hydric soils and floodplains was given a score of 1 for all parameters in both forest stands. Once again, the "patch" nature of The Woods limits that ability for plants and animals to migrate to and from other forested areas, however, The Woods may also be acting as an island refuge for these species. Eventually though these species may naturally become extirpated from The Woods due to lack of genetic diversity or mating opportunities.

5.0 CONCLUSIONS

As stated previously, the results of the Land Suitability Index are used only to ordinate the potential site locations. In this case the potential facility locations were evaluated and not the entirety of The Woods. The numbers derived are only a means for comparison and are not actual quantitative values. The results of this study show that the tennis court site, with an overall score of 7, would be a preferred alternative site, from an ecological perspective, for the construction of the indoor practice facility rather than The Woods site which has an overall score of 31. The alternative site, while still predominantly affecting the tennis courts and open space, intrudes into The Woods and thereby has a significant enough impact to warrant a score of 28. The potential presence of rare, threatened and endangered species would warrant that additional consultation with FWS and DCR, and perhaps targeted species surveys, be conducted to determine the full potential impact to these species at The Woods site and the alternative site.

The results of the i-Tree analysis shows that the loss of forest within the proposed construction footprint associated with the indoor practice facility at The Woods and the alternative site would have a negative effect on the ability of The Woods to provide natural capital in terms of carbon sequestration, carbon storage and air pollutant removal. The forest that would potentially be removed in association with The Woods sites would result in the loss of $1.16 million in forest structure and a loss of $318,600 at the alternative site location. This information also does not take into consideration the water quality or habitat value that The Woods provides.

The forest condition scoring was used to evaluate ecological aspects of the two forest stands within The Woods on an absolute scale. Unlike the LSI, this evaluation is not used as a ranking exercise, but can be used to make direct comparisons between forest stands. The results show that both The Woods north and south, with scores of 24 and 30 respectively, rank in the middle of the range for this evaluation (total FCS range= -8 to 67). The metrics related to the forest structure ranked fairly high, however the presence of invasive species in both forest stands had negative effects on the overall score. Similarly, the proximity of The Woods to other natural features, that may potentially increase the habitat diversity, also scored very low. The low scores of proximity metrics cannot easily be rectified without reforestation and/or restoration projects and even then, it would take a significant amount of time for these project to develop the ecosystem function required for the scores to be brought up to higher levels. The negative scores received due to the presence of invasive species can however be easily mitigated through the development of a forest management plans that targets the selective removal of exotic invasive species.

The presence of The Woods as a patch that may provide a migration route for animals from one corridor to another, or in between patches, could be critical to the flora and fauna of the area surrounding Virginia Tech and Blacksburg. Based upon aerial photography, The Woods could provide a critical linkage between Paris and Hightop Mountain to the east and Brush Mountain to the west. Without The Woods, animals and plants may find it difficult to make the passage between these two corridors. Few other patches exist that could potentially provide the necessary linkage. The lack of migration between corridors could essentially prohibit the intermixing of breeding populations of some species and therefore reduce genetic diversity at local level. While this is of small consequence to species with large populations, it could lead to the extirpation of RT&E species with fewer individuals that may already have diminished genetic diversity.

The location of the facility within The Woods north would also have the affect of essentially dividing The Woods into two forest patches. The Woods south would remain largely intact; however The Woods north would now essentially be a stand-alone forest. This forest stand would now be only three (3) acres in size and would reduce the amount of available food and habitat directly from the removal of the forest. The Woods north would be further degraded into a forest dominated by forest edge type habitat. The edge habitat that would be created is conducive for invasive species, but more importantly limits the available shelter for animals and plants that prefer the safety of habitats further from open spaces. The presence of a large building adjacent to the remaining forest also reduces its usefulness to birds and mammals. The hard structure of the façade of the building limits pathways into and out of the remaining forest, thereby making it less desirable to inhabit for reasons such as a limited number of escape routes from predators. The Woods north would still serve some ecological value in terms of nutrient cycling, pollution mitigation, carbon sequestration, but from a habitat standpoint it would be reduced to a fraction of what it once was when it was contiguous with The Woods South.

As a smaller forest, many of the LSI metrics may decrease simply due to the fact that the ability to mitigate for a three acre forest is much easier than mitigating for a six acre forest. The loss of structure and diversity as well as the likelihood for the increase of invasive species would most certainly lower the overall score, making the site less desirable for conservation.

The alternative site location does not have the same affect of dividing The Woods north into two small patches and would be preferred over the initial location which proposes greater forest impacts. The alternative site location would require the removal of approximately 0.8 acres of forest while The Woods location would require the removal of 3 acres of forest. Although the forest impacts are lessened at the alternative site location, the loss of several significant trees would be unavoidable.

In order to offset the effects of the removal of a portion of The Woods north, additional trees could be planted in the open areas to the north between the tennis courts and Cranwell International Center. While this may prevent the overall forested area from being reduced significantly, the benefits would not be seen until the reforested area matured into a late successional forest which could take several decades. Providing additional understory along the eastern portions of The Woods could help to increase the diversity and habitat available, but this understory would not suffice to replace the value and structure of the lost overstory trees. Off-site reforestation, while beneficial overall, typically does not mitigate for the loss of habitat in the immediate vicinity. Two small forest patches typically do not serve the same function as one larger forest patch of equal size; they only contribute to forest edge habitat and invasive species problems.

An analysis of the critical root zone to determine the impact that the facility would have on trees adjacent to the proposed facility in The Woods was also conducted. The critical root zone is an area equal to 1.5 feet in radius for every one (1) inch of the diameter of the tree. An impact to greater than 30% of this root zone may result in the death of the associated tree. Within the building construction footprint for The Woods, 100 trees greater than 10 inches in diameter would be removed (Appendix S). The results of the critical root zone evaluation for this site indicate that 17 additional trees that lie outside of the proposed construction footprint may be impacted to the point that mortality of the tree is eminent. The impact of trees at the alternative site indicates that 55 trees may be removed or destroyed as a result of this facility, 4 of which due to critical root zone impacts (Appendix S). One of the largest white oaks on-site (53” DBH) would be within the construction footprint of the facility and therefore would be lost. This tree may be as old as 450 years based upon a calibrated growth factor of approximately 8.65. A map and list of these trees within both proposed sites may be found in Appendix S.

In general the abundance of large white oak and black oak trees within The Woods as well as the diverse age class structure are the most beneficial factors of this forested area from a habitat and ecosystem function and process perspective. The isolation of this forested patch is a hindrance from the perspective that it is not easy for less mobile species to migrate in and out of The Woods. On the other hand though, The Woods may act as a forested island that provides refuge and a stepping stone for some species that may be navigating from one migration corridor to another.

From an ecological perspective, the tennis court site would be the preferred site for the proposed indoor practice facility and The Woods north site would be the least preferred option. The alternative site, while still having potentially significant ecological impacts, would be preferred over The Woods north site due to fewer tree losses and a reduction in the amount of edge habitat that would be created by The Woods north site.

6.0 REFERENCES

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APPENDIX A

SITE MAP

Drillfield Dr
Washington St SW
Clay St SW
Miller St
S Main St
Eheart St SW
Eakin St SW
Church St SE
Hemlock Dr SE
Upland Rd
Vanderpan Rd
Branch
460
Grove Ln
Oak Ln
Houston St
Clay Circle
Harrell St
Preston Ave
Hemlock Dr SW
Cassell Coliseum
Center St
Warren St
Gracelyn Ct
Draper Rd SW
Smithfield Rd
Duckpond Dr
Washington St
Stadium Rd
Green St
Lane Stadium
Sterrett Dr
Edgewood Ln
Allendale Ct
Airport Rd
Dunton Dr
Draper Rd SW
Southgate Dr
Gate Dr
Overlook Dr
Skyview Dr
Country Club Dr
Monte Vista Dr
Tech Center Dr
(c) 2009 Microsoft Corporation and its data suppliers
http://www.bing.com/maps
VirginiaTech
Biohabitats
Vicinity Map
Virginia Tech - The Woods
N
500 250 0 500 1,000 1,500 2,000
Feet

WASHINGTON STREET
The Woods North
The Woods South
VirginiaTech
Biohabitats
Forest Canopy & Understory
Virginia Tech - The Woods
Proposed Construction Area
Forest Understory (11.8 Acres)
Forest Canopy (13.75 Acres)
100 50 0 100 200 300 400
Feet
N

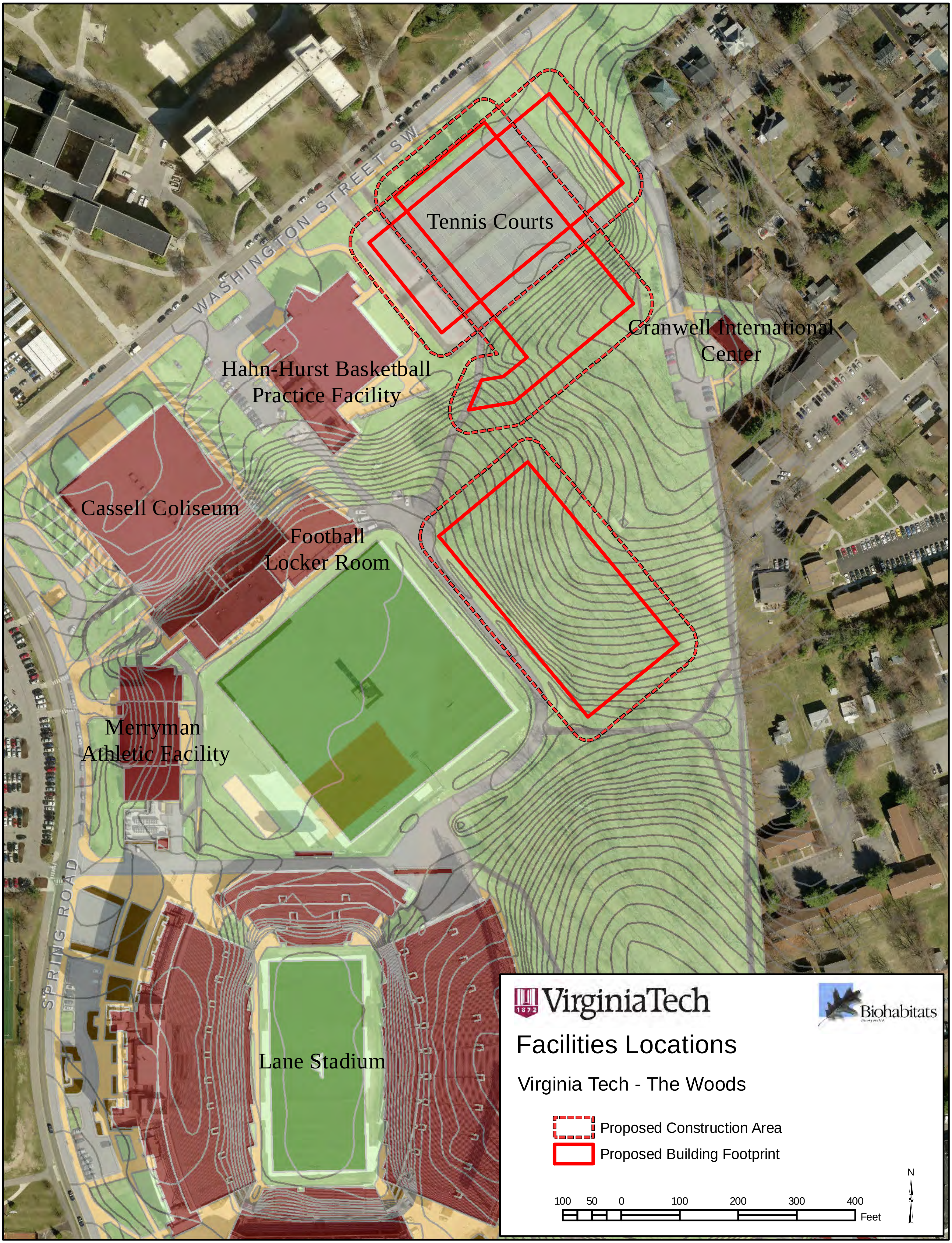
APPENDIX B

PATCH MAP

VirginiaTech
Biohabitats
Patch Connectivity
Virginia Tech - The Woods
1
0.5
0
1
2
Miles
N
Northend
Branch
Woodbine/Wyatt
Northside Park
460
Mount Tabor
Main/Patrick Henry
N Main St
Murphy
Tom's Creek
Shenandoah
Patrick Henry Dr
Harding Rd
Shadowlake Rd
Toms Creek Rd
Kabrich Crescent
McBryde
Harding Ave
Kanodes Mill
Glade/Westover
Alleghany
Glade Rd
Montgomery
Blacksburg
Prices Fork Rd
University
Lane Stadium
Miller
Southside
412
Virginia Polytechnic Institute and State University
Grissom/Highland
Hethwood/Prices Fork
Nellies Cave Rd
Prices Fork Rd
Merrimac Rd
Tall Oaks Dr
Airport Acres
S Main St
Prices Fork
Ellett Rd
Farmview/Ramble
Branch
New Ellett
Cedar Run Rd
Oilwell Rd
Huff Ln
Forest Service Rd
Edison Ln
Bishop

APPENDIX C

FACILITY LOCATIONS



WASHINGTON STREET SW
Tennis Courts
Cranwell International Center
Hahn-Hurst Basketball Practice Facility
Cassell Coliseum
Football Locker Room
Merryman Athletic Facility
SPRING ROAD
Lane Stadium
VirginiaTech
1872
Biohabitats
Facilities Locations
Virginia Tech - The Woods
Proposed Construction Area
Proposed Building Footprint
100 50 0 100 200 300 400
Feet
N

APPENDIX D

LAND SUITABILITY METRIC SHEETS

Virginia Tech The Woods
Land Suitability Metrics

Site Element	Disturbance Will Result in No or Marginal Ecological Impact	Disturbance Acceptable If BMPs or Restrictions Are Applied	Disturbance will Compromise Ecological Integrity	Regulatory Restrictions or Conservation Area	Land Suitability Index*
	Class. 0-No Impact Class. 1- Marginal Impact	Classification 2	Classification 3	Classification +1	
Streams					
Hydrologic Regime[1]					
Ephemeral	1				1
Intermittent	0				0
Perennial	0				0
Buffers[2]					
Regulatory Buffer	0				0
100ft Conservation Buffer	0				0
Floodplains[3]					
Regulatory 100 yr floodplain	0				0
Morphological 50 yr floodplain	0				0
Aquatic Habitat[4]					
Aquatic Habitat-High Quality	0				0
Aquatic Habitat-Mod Quality	0				0
Aquatic Habitat-Low Quality	0				0
Wetlands[5]					
Hydric Soils					
Hydric Soils	0				0
Non-hydric soils	0				0
Wetland Size					
Area < 0.1 ac	0				0
Area 0.1-.33 ac	0				0
Area > 0.33 ac	0				0
Special Isolated Wetland Type					
Vernal Pool	0				0
Springs and Seeps	0				0
Wetland Buffer[6]					
0-25' Conservation Bufer	0				0
>25' Conservation Buffer	0				0
Groundwater[7]					
Recharge Zones					
Pervious Saturated Hydraulic Cond	0				0
Semi-pervious Saturated Hydraulic Cond	1				1
Impervious Saturated Hydraulic Cond	0				0
Geomorphology					
Erodability[7]					
Erodibility K Factor <0.35	0				0
Erodibility K Factor >0.35	0				0
Slope					
Slopes 0-15%	0				0
Slopes 15-25%	0				0
Slopes >25%	0				0
Vegetation					
Rare Species					
Potential RTE Species Location		2			2
Potential RTE Habitat			3		3
Tree Age					
Tree Age Class 0-50 yrs		2			2
Tree Age Class 51-75 yrs			3		3
Tree Age Class >75 yrs			3		3

Virginia Tech The Woods
Land Suitability Metrics

Site Element	Disturbance Will Result in No or Marginal Ecological Impact	Disturbance Acceptable If BMPs or Restrictions Are Applied	Disturbance will Compromise Ecological Integrity	Regulatory Restrictions or Conservation Area	Land Suitability Index*
	Class. 0-No Impact Class. 1- Marginal Impact	Classification 2	Classification 3	Classification +1	
Vegetation (continued)					
Tree Species Abundance[8]					
Species Abundance - High		2			**2**
Species Abundance - Mod.	0				**0**
Species Abundance - Low	0				**0**
Landscape Ecology					
Corridor Regional Importance[9]					
Primary Corridors	0				**0**
Secondary Corridors	0				**0**
Isolated Corridors	0				**0**
Adjacent Corridor Distance					
0-1.5 Kilometers	0				**0**
> 1.5 km	0				**0**
Patch Structural Integrity					
Solid->90% forest cover		2			**2**
Porous-50-90% forest cover	0				**0**
Stepping Stone-<50% forest cover	0				**0**
Total Patch Size[10]					
Forested Habitat Patch > 40 ac	0				**0**
Forested Habitat Patch 25-39 ac	0				**0**
Forested Habitat Patch <25 ac			3		**3**
Interior Forest Patch Size[10]					
Forested Habitat Patch > 40 ac	0				**0**
Forested Habitat Patch 25-39 ac	0				**0**
Forested Habitat Patch 0-24 ac	0				**0**
Adjacent Patch Distance					
0-0.5 Kilometers	0				**0**
0.5-1.5 Kilometers	0				**0**
> 1.5 Kilometers	0				**0**
Wildlife Habitat					
Rare,Threat. or Spec. Species Hab.					
Hardwoods > 50 yrs old			3		**3**
Hardwoods < 50 yrs old			3		**3**
Avian Habitat			3		**3**
Vernal Pool	0				**0**
					31

*Land Suitability Index-Value used to categorize respective attribute in GIS

[1] The stream regime designations were determined in the field by Biohabitats.

[2] The regulatory stream buffer lines are based on Biohabitats field calls on intermittent and perennial stream

[3] The 100 year floodplain was taken from FEMA Floodmaps data and the 50 year floodplain was estimated using GIS if relevant.

[4]Aquatic habitat quality was determined by a qualitative field assessment of stream channel morpology and habitat quality, which was then converted to a numerical score. Ranges for High, Moderate and Low were developed based on the characteristics of the site and data set.

[5]Wetland area ranges based on State and Federal regulations.

[6]Buffer width based upon State and Federal regulations.

[7]Montgomery County Soil Survey, Natural Resource Conservation Service, USDA (Web Soil Survey).

[8]Relative species abundance determined from field assessment.

[9]Landscape ecology corridor widths determined through synthesis of peer-reviewed literature.

[10]Patch size ranges determined through synthesis of peer-reviewed literature.

Biohabitats

Virginia Tech Tennis Courts
Land Suitability Metrics

Site Element	Disturbance Will Result in No or Marginal Ecological Impact	Disturbance Acceptable If BMPs or Restrictions Are Applied	Disturbance will Compromise Ecological Integrity	Regulatory Restrictions or Conservation Area	Land Suitability Index*
	Class. 0-No Impact Class. 1- Marginal Impact	Classification 2	Classification 3	Classification +1	
Streams					
Hydrologic Regime[1]					
Ephemeral	0				**0**
Intermittent	0				**0**
Perennial	0				**0**
Buffers2					
Regulatory Buffer	0				**0**
100ft Conservation Buffer	0				**0**
Floodplains3					
Regulatory 100 yr floodplain	0				**0**
Morphological 50 yr floodplain	0				**0**
Aquatic Habitat4					
Aquatic Habitat-High Quality	0				**0**
Aquatic Habitat-Mod Quality	0				**0**
Aquatic Habitat-Low Quality	0				**0**
Wetlands5					
Hydric Soils					
Hydric Soils	0				**0**
Non-hydric soils	0				**0**
Wetland Size					
Area < 0.1 ac	0				**0**
Area 0.1-.33 ac	0				**0**
Area > 0.33 ac	0				**0**
Special Isolated Wetland Type					
Vernal Pool	0				**0**
Springs and Seeps	0				**0**
Wetland Buffer6					
0-25' Conservation Bufer	0				**0**
>25' Conservation Buffer	0				**0**
Groundwater7					
Recharge Zones					
Pervious Saturated Hydraulic Cond	0				**0**
Semi-pervious Saturated Hydraulic Cond	0				**0**
Impervious Saturated Hydraulic Cond	0				**0**
Geomorphology					
Erodability7					
Erodibility K Factor <0.35	0				**0**
Erodibility K Factor >0.35	0				**0**
Slope					
Slopes 0-15%	0				**0**
Slopes 15-25%	1				**1**
Slopes >25%	0				0
Vegetation					
Rare Species					
Potential RTE Species Location	0				**0**
Potential RTE Habitat	0				**0**
Tree Age					
Tree Age Class 0-50 yrs		2			**2**
Tree Age Class 51-75 yrs		2			**2**
Tree Age Class >75 yrs	0				**0**

Vegetation (continued)		
Tree Species Abundance8		
Species Abundance - High	0	**0**
Species Abundance - Mod.	0	**0**
Species Abundance - Low	1	**1**
Landscape Ecology		
Corridor Regional Importance9		
Primary Corridors	0	**0**
Secondary Corridors	0	**0**
Isolated Corridors	0	**0**
Adjacent Corridor Distance		
0-1.5 Kilometers	0	**0**
> 1.5 km	0	**0**
Patch Structural Integrity		
Solid->90% forest cover	0	**0**
Porous-50-90% forest cover	0	**0**
Stepping Stone-<50% forest cover	0	**0**
Total Patch Size10		
Forested Habitat Patch > 40 ac	0	**0**
Forested Habitat Patch 25-39 ac	0	**0**
Forested Habitat Patch <25 ac	0	**0**
Interior Forest Patch Size10		
Forested Habitat Patch > 40 ac	0	**0**
Forested Habitat Patch 25-39 ac	0	**0**
Forested Habitat Patch 0-24 ac	0	**0**
Adjacent Patch Distance		
0-0.5 Kilometers	0	**0**
0.5-1.5 Kilometers	0	**0**
> 1.5 Kilometers	0	**0**
Wildlife Habitat		
Rare,Threat. or Spec. Species Hab.		
Hardwoods > 50 yrs old	0	**0**
Hardwoods < 50 yrs old	0	**0**
Avian Habitat	1	**1**
Vernal Pool	0	**0**
		7

*Land Suitability Index-Value used to categorize respective attribute in GIS

[1] The stream regime designations were determined in the field by Biohabitats.

[2] The regulatory stream buffer lines are based on Biohabitats field calls on intermittent and perennial stream

[3] The 100 year floodplain was taken from FEMA Floodmaps data and the 50 year floodplain was estimated using GIS if relevant.

[4]Aquatic habitat quality was determined by a qualitative field assessment of stream channel morpology and habitat quality, which was then converted to a numerical score. Ranges for High, Moderate and Low were developed based on the characteristics of the site and data set.

[5]Wetland area ranges based on State and Federal regulations.

[6]Buffer width based upon State and Federal regulations.

[7]Montgomery County Soil Survey, Natural Resource Conservation Service, USDA (Web Soil Survey).

[8]Relative species abundance determined from field assessment.

[9]Landscape ecology corridor widths determined through synthesis of peer-reviewed literature.

[10]Patch size ranges determined through synthesis of peer-reviewed literature.

Biohabitats

Alternative Site
Land Suitability Metrics

Site Element	Disturbance Will Result in No or Marginal Ecological Impact	Disturbance Acceptable If BMPs or Restrictions Are Applied	Disturbance will Compromise Ecological Integrity	Regulatory Restrictions or Conservation Area	Land Suitability Index*
	Class. 0-No Impact Class. 1- Marginal Impact	Classification 2	Classification 3	Classification +1	
Streams					
Hydrologic Regime[1]					
Ephemeral	0				**0**
Intermittent	0				**0**
Perennial	0				**0**
Buffers2					
Regulatory Buffer	0				**0**
100ft Conservation Buffer	0				**0**
Floodplains3					
Regulatory 100 yr floodplain	0				**0**
Morphological 50 yr floodplain	0				**0**
Aquatic Habitat4					
Aquatic Habitat-High Quality	0				**0**
Aquatic Habitat-Mod Quality	0				**0**
Aquatic Habitat-Low Quality	0				**0**
Wetlands5					
Hydric Soils					
Hydric Soils	0				**0**
Non-hydric soils	0				**0**
Wetland Size					
Area < 0.1 ac	0				**0**
Area 0.1-.33 ac	0				**0**
Area > 0.33 ac	0				**0**
Special Isolated Wetland Type					
Vernal Pool	0				**0**
Springs and Seeps	0				**0**
Wetland Buffer6					
0-25' Conservation Bufer	0				**0**
>25' Conservation Buffer	0				**0**
Groundwater7					
Recharge Zones					
Pervious Saturated Hydraulic Cond	0				**0**
Semi-pervious Saturated Hydraulic Cond	1				**1**
Impervious Saturated Hydraulic Cond	0				**0**
Geomorphology					
Erodability7					
Erodibility K Factor <0.35	0				**0**
Erodibility K Factor >0.35	0				**0**
Slope					
Slopes 0-15%	0				**0**
Slopes 15-25%	1				**1**
Slopes >25%	0				0
Vegetation					
Rare Species					
Potential RTE Species Location		2			**2**
Potential RTE Habitat			3		**3**
Tree Age					
Tree Age Class 0-50 yrs		2			**2**
Tree Age Class 51-75 yrs		2			**2**
Tree Age Class >75 yrs			3		**3**

Vegetation (continued)				
Tree Species Abundance8				
Species Abundance - High		2		**2**
Species Abundance - Mod.	0			**0**
Species Abundance - Low	0			**0**
Landscape Ecology				
Corridor Regional Importance9				
Primary Corridors	0			**0**
Secondary Corridors	0			**0**
Isolated Corridors	0			**0**
Adjacent Corridor Distance				
0-1.5 Kilometers	0			**0**
> 1.5 km	0			**0**
Patch Structural Integrity				
Solid->90% forest cover	0			**0**
Porous-50-90% forest cover	0			**0**
Stepping Stone-<50% forest cover		2		**2**
Total Patch Size10				
Forested Habitat Patch > 40 ac	0			**0**
Forested Habitat Patch 25-39 ac	0			**0**
Forested Habitat Patch <25 ac		2		**2**
Interior Forest Patch Size10				
Forested Habitat Patch > 40 ac	0			**0**
Forested Habitat Patch 25-39 ac	0			**0**
Forested Habitat Patch 0-24 ac	0			**0**
Adjacent Patch Distance				
0-0.5 Kilometers	0			**0**
0.5-1.5 Kilometers	0			**0**
> 1.5 Kilometers	0			**0**
Wildlife Habitat				
Rare,Threat. or Spec. Species Hab.				
Hardwoods > 50 yrs old			3	**3**
Hardwoods < 50 yrs old			3	**3**
Avian Habitat		2		**2**
Vernal Pool	0			**0**
				28

*Land Suitability Index-Value used to categorize respective attribute in GIS

[1] The stream regime designations were determined in the field by Biohabitats.

[2] The regulatory stream buffer lines are based on Biohabitats field calls on intermittent and perennial stream

[3] The 100 year floodplain was taken from FEMA Floodmaps data and the 50 year floodplain was estimated using GIS if relevant.

[4]Aquatic habitat quality was determined by a qualitative field assessment of stream channel morpology and habitat quality, which was then converted to a numerical score. Ranges for High, Moderate and Low were developed based on the characteristics of the site and data set.

[5]Wetland area ranges based on State and Federal regulations.

[6]Buffer width based upon State and Federal regulations.

[7]Montgomery County Soil Survey, Natural Resource Conservation Service, USDA (Web Soil Survey).

[8]Relative species abundance determined from field assessment.

[9]Landscape ecology corridor widths determined through synthesis of peer-reviewed literature.

[10]Patch size ranges determined through synthesis of peer-reviewed literature.

Metric	Score		
	Stadium Woods	Tennis Courts	Rotated
Streams	1	0	0
Wetlands	0	0	0
Groundwater	1	0	1
Geomorphology	0	1	1
Vegetation	15	5	14
Landscape Ecology	5	0	4
Wildlife Habitat	9	1	8
Total Score	**31**	**7**	**28**

APPENDIX E

LSI STREAMS


WASHINGTON STREET
Basketball Practice Facility
0
1
Cranwell International Center
VirginiaTech
1872
Biohabitats
Land Suitability Index - Streams
Virginia Tech - The Woods
Proposed Construction Area
50 25 0 50 100 150 200
Feet
N


WASHINGTON STREET
Basketball Practice Facility
0
Cranwell International Center
VirginiaTech
Biohabitats
Land Suitability Index - Streams
Virginia Tech - Alternative Site
Proposed Construction Area
50 25 0 50 100 150 200
Feet
N

APPENDIX F

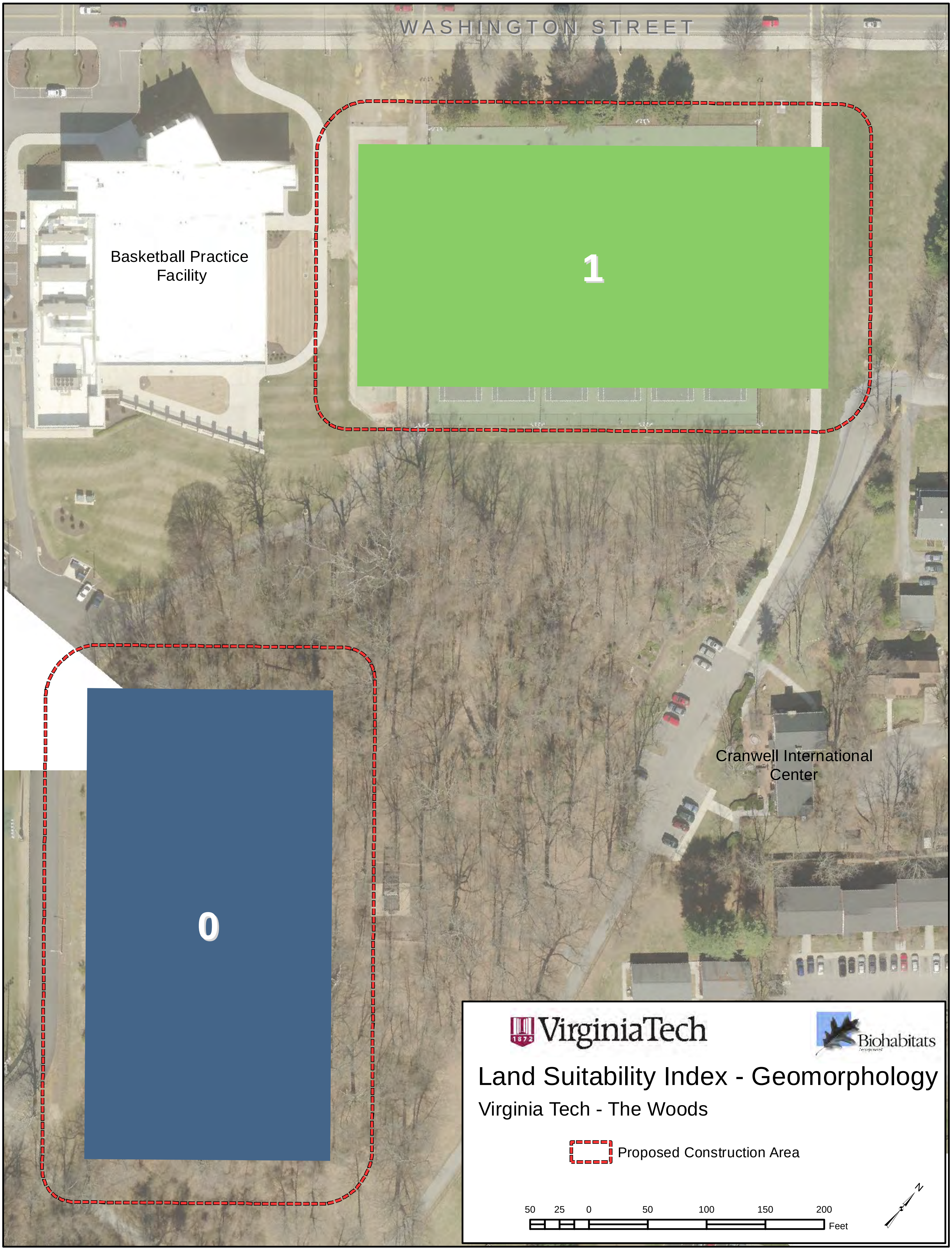
LSI GROUNDWATER

WASHINGTON STREET
Basketball Practice Facility
0
1
Cranwell International Center
VirginiaTech
Biohabitats
Land Suitability Index - Groundwater
Virginia Tech - The Woods
Proposed Construction Area
50 25 0 50 100 150 200
Feet
N


WASHINGTON STREET
Basketball Practice Facility
1
Cranwell International Center
VirginiaTech
Biohabitats
Land Suitability Index - Groundwater
Virginia Tech - Alternative Site
Proposed Construction Area
50 25 0 50 100 150 200
Feet
N

APPENDIX G

LSI GEOMORPHOLOGY

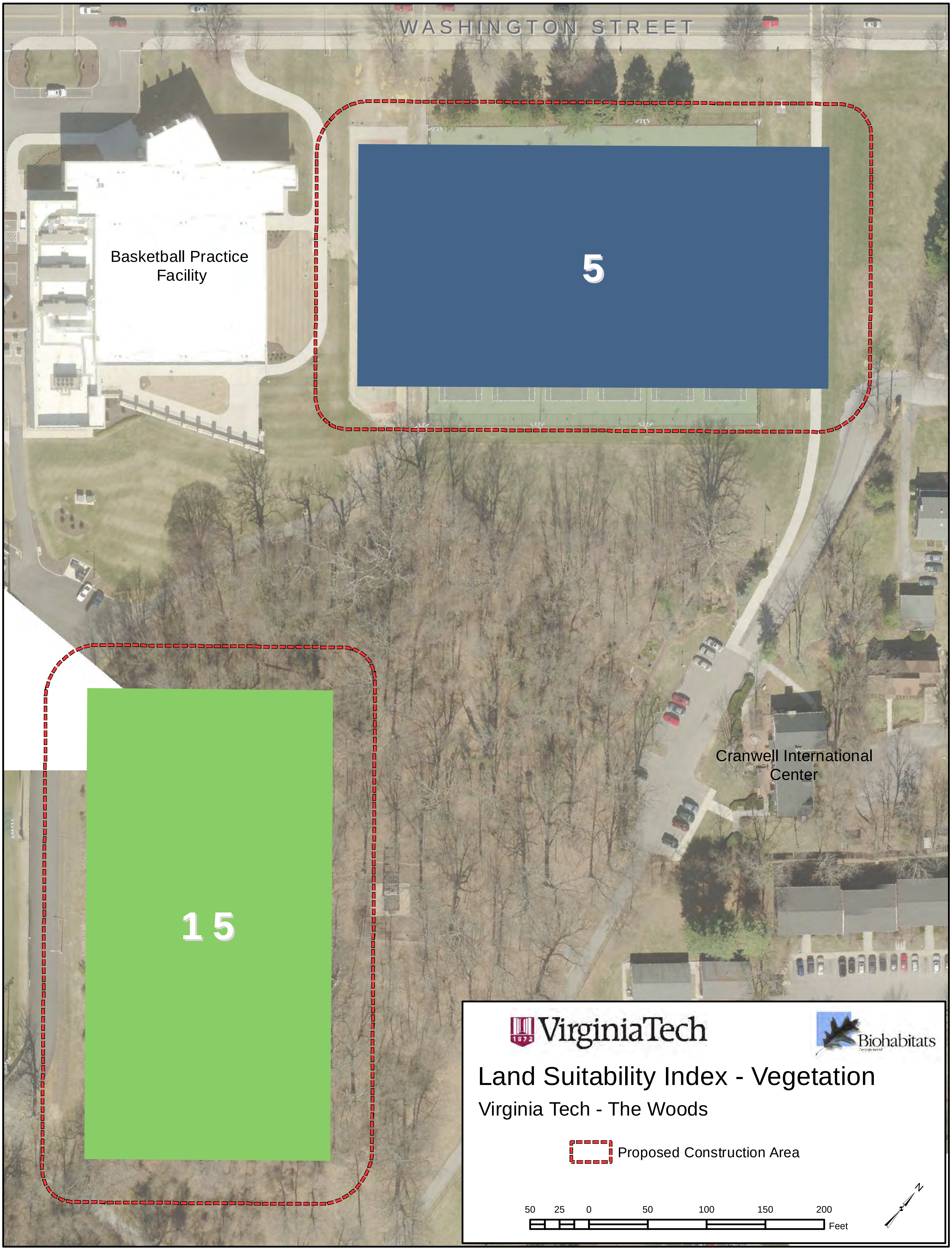


WASHINGTON STREET
Basketball Practice Facility
1
0
Cranwell International Center
VirginiaTech
Biohabitats
Land Suitability Index - Geomorphology
Virginia Tech - The Woods
Proposed Construction Area
50 25 0 50 100 150 200
Feet
N

WASHINGTON STREET
Basketball Practice Facility
1
Cranwell International Center
VirginiaTech
Biohabitats
Land Suitability Index - Geomorphology
Virginia Tech - Alternative Site
Proposed Construction Area
50 25 0 50 100 150 200
Feet
N

APPENDIX H

LSI VEGETATION

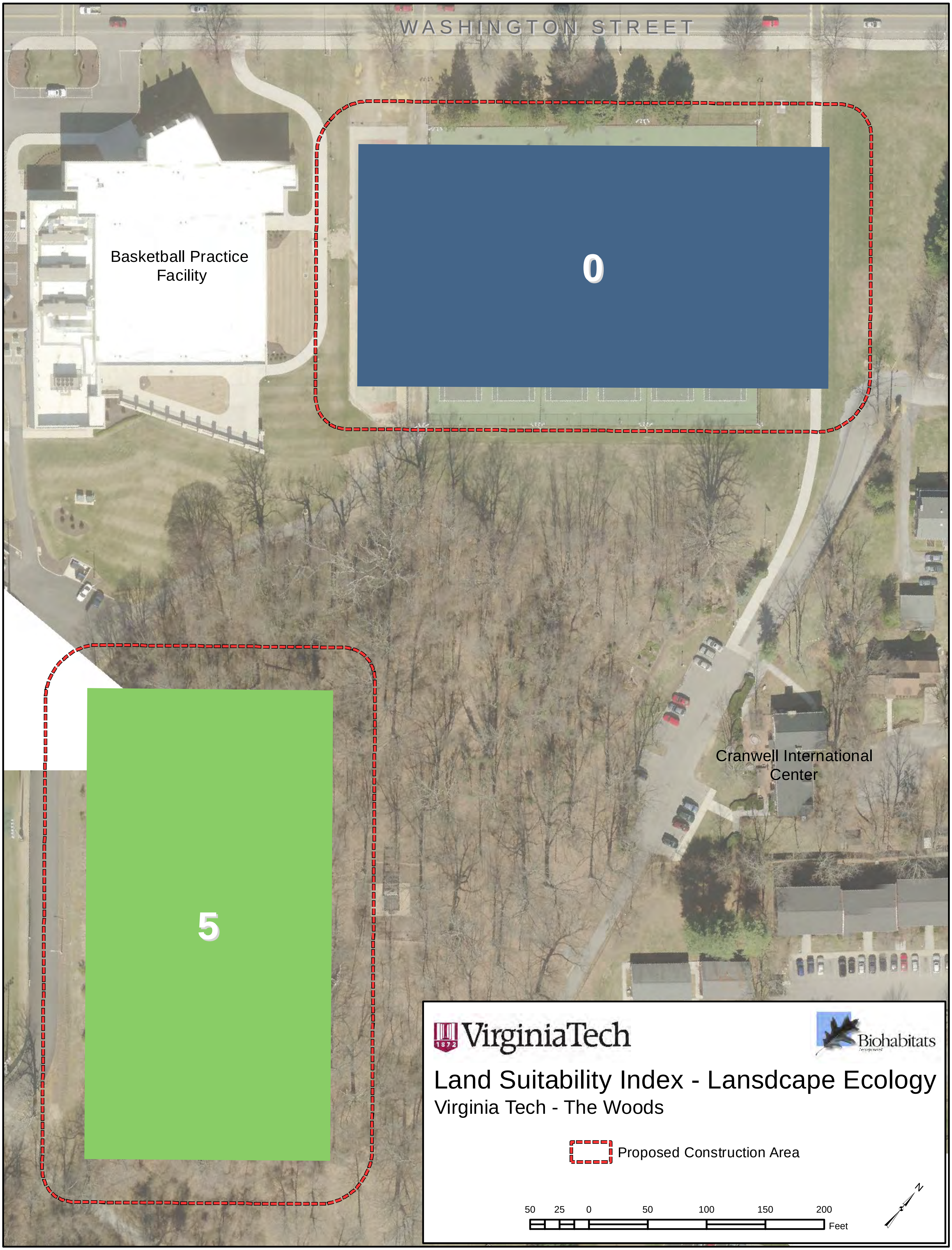

WASHINGTON STREET
Basketball Practice Facility
5
15
Cranwell International Center
VirginiaTech
1872
Biohabitats
Land Suitability Index - Vegetation
Virginia Tech - The Woods
Proposed Construction Area
50 25 0 50 100 150 200
Feet
N

Land Suitability Index - Vegetation

Virginia Tech - Alternative Site

APPENDIX I

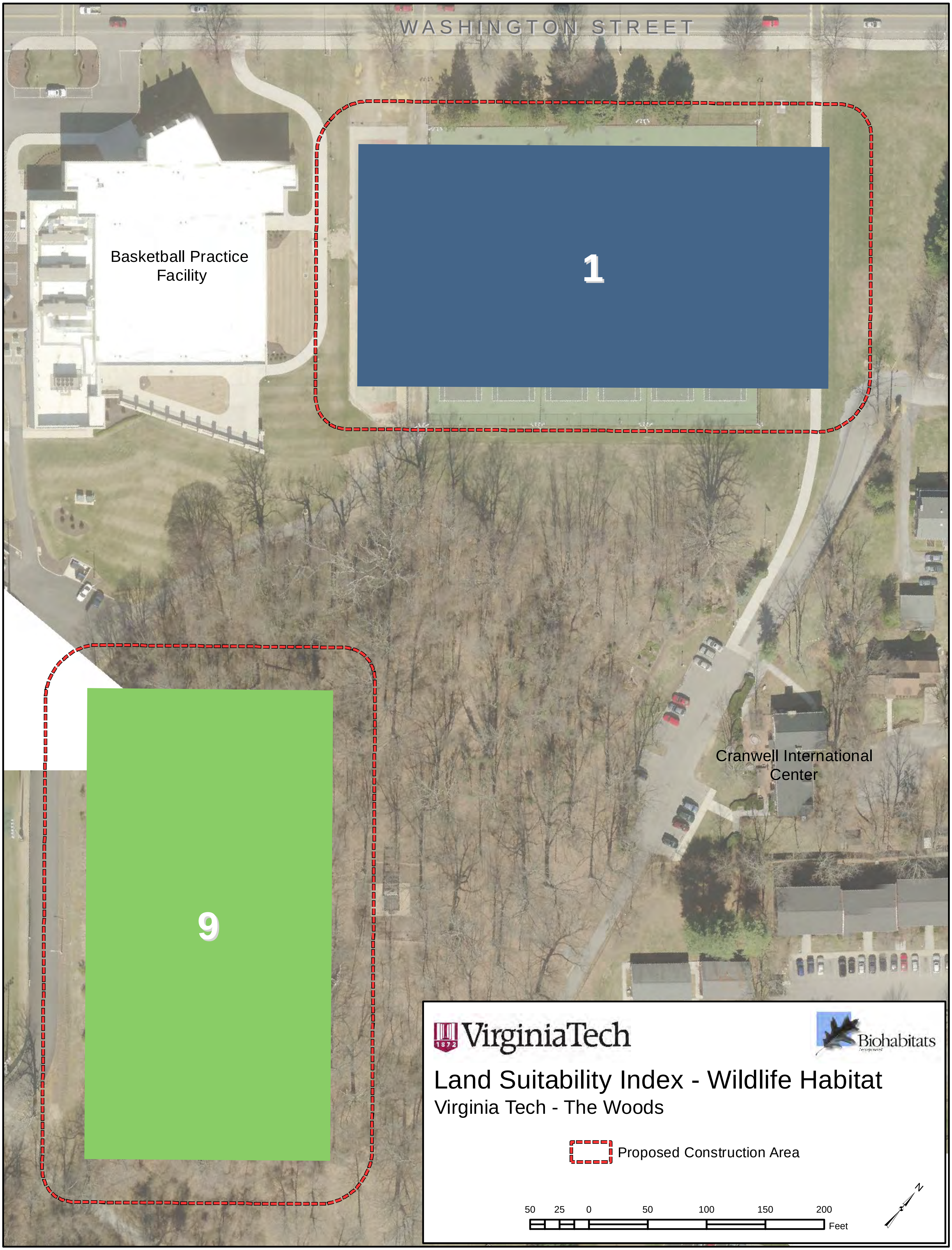
LSI LANDSCAPE


WASHINGTON STREET
Basketball Practice Facility
0
5
Cranwell International Center
VirginiaTech
Biohabitats
Land Suitability Index - Lansdcape Ecology
Virginia Tech - The Woods
Proposed Construction Area
50 25 0 50 100 150 200
Feet
N


WASHINGTON STREET
Basketball Practice Facility
4
Cranwell International Center
VirginiaTech
Biohabitats
Land Suitability Index - Lansdcape Ecology
Virginia Tech - Alternative Site
Proposed Construction Area
50 25 0 50 100 150 200
Feet
N

APPENDIX J

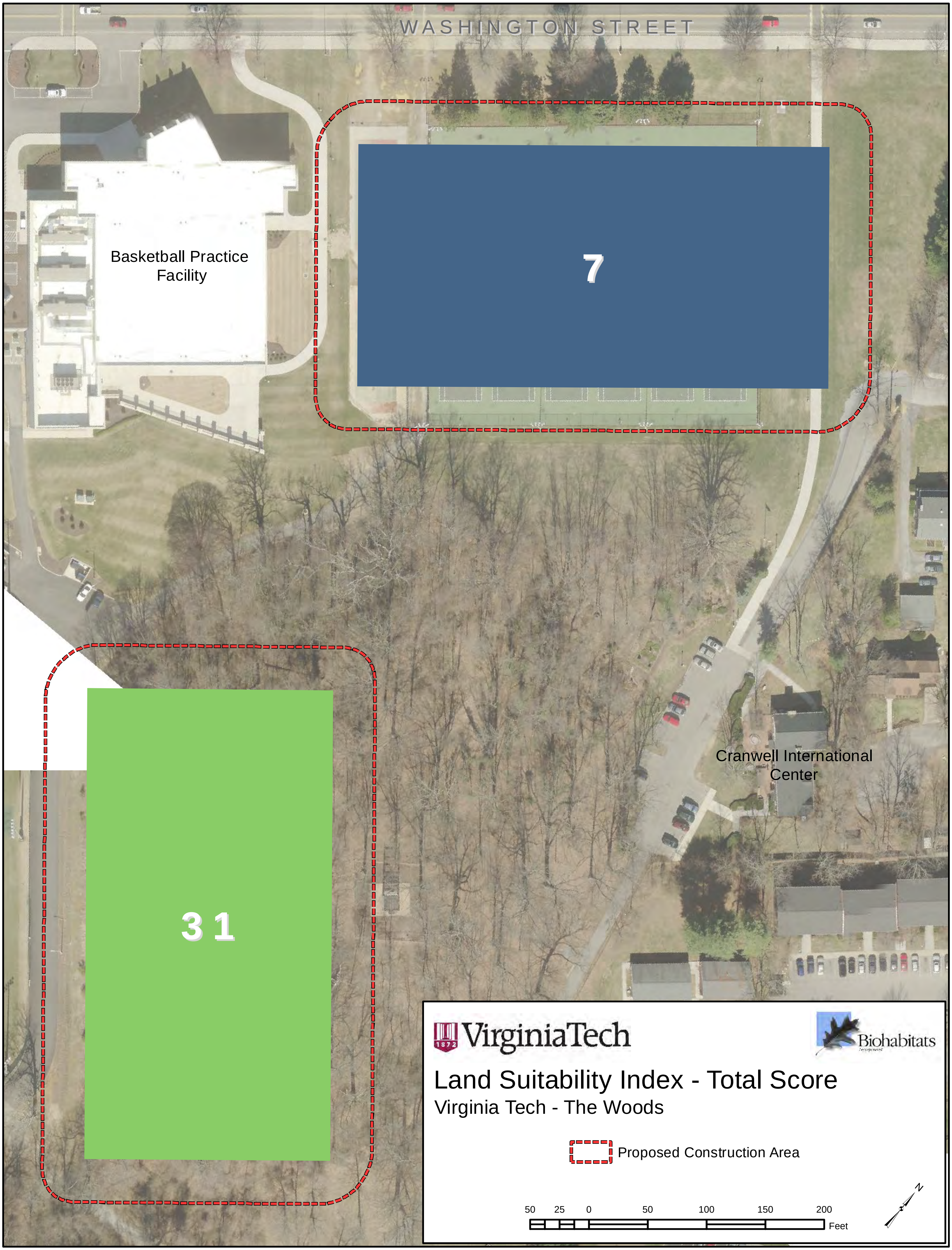
LSI WILDLIFE


WASHINGTON STREET
Basketball Practice Facility
1
9
Cranwell International Center
VirginiaTech
Biohabitats
Land Suitability Index - Wildlife Habitat
Virginia Tech - The Woods
Proposed Construction Area
50 25 0 50 100 150 200
Feet
N


WASHINGTON STREET
Basketball Practice Facility
8
Cranwell International Center
VirginiaTech
Biohabitats
Land Suitability Index - Wildlife Habitat
Virginia Tech - Alternative Site
Proposed Construction Area
50 25 0 50 100 150 200
Feet
N

APPENDIX K

LSI TOTAL SCORE



Land Suitability Index - Total Score

Virginia Tech - The Woods

WASHINGTON STREET
Basketball Practice Facility
28
Cranwell International Center
VirginiaTech
Biohabitats
Land Suitability Index - Total Score
Virginia Tech - Alternative Site
Proposed Construction Area
50 25 0 50 100 150 200
Feet
N

APPENDIX L

I-TREE REPORT

i-Tree
Ecosystem Analysis

Virginia Tech

Urban Forest Effects and Values
April 2012

i-Tree

UFORE
Urban Forest Effects Model

Summary

Understanding an urban forest's structure, function and value can promote management decisions that will improve human health and environmental quality. An assessment of the vegetation structure, function, and value of the Virginia Tech urban forest was conducted during 2012. Data from 2 field plots located throughout Virginia Tech were analyzed using the Urban Forest Effects (UFORE) model developed by the U.S. Forest Service, Northern Research Station.

Key findings

- Number of trees: 3,840
- Tree cover: 80.5%
- Most common species: Sweet cherry, White oak, Flowering dogwood
- Percentage of trees less than 6" (15.2 cm) diameter: 71.9%
- Pollution removal: 1 tons/year ($5.19 thousand/year)
- Carbon storage: 608 tons ($11.2 thousand)
- Carbon sequestration: 21 tons/year ($389/year)
- Building energy savings: $0 / year
- Avoided carbon emissions: $0 / year
- Structural values: $5.31 million

Ton: short ton (U.S.) (2,000 lbs)
Carbon storage: the amount of carbon bound up in the above-ground and below-ground parts of woody vegetation
Carbon sequestration: the removal of carbon dioxide from the air by plants through photosynthesis
Structural value: value based on the physical resource itself (e.g., the cost of having to replace a tree with a similar tree)
Monetary values($) reported in US Dollar throughout report except where noted

For an overview of UFORE methodology, see Appendix I. Data collection quality is determined by the local data collectors, over which i-Tree has no control. Additionally, some of the plot and tree information may not have been collected, so not all of the analyses may have been conducted for this report.

Table of Contents

I. Tree Characteristics of the Urban Forest

The urban forest of Virginia Tech has an estimated 3,840 trees with a tree cover of 80.5 percent. Trees that have diameters less than 6-inches (15.2 cm) constitute 71.9 percent of the population. The three most common species are Sweet cherry (37.50 percent), White oak (10.90 percent), and Flowering dogwood (9.38 percent).

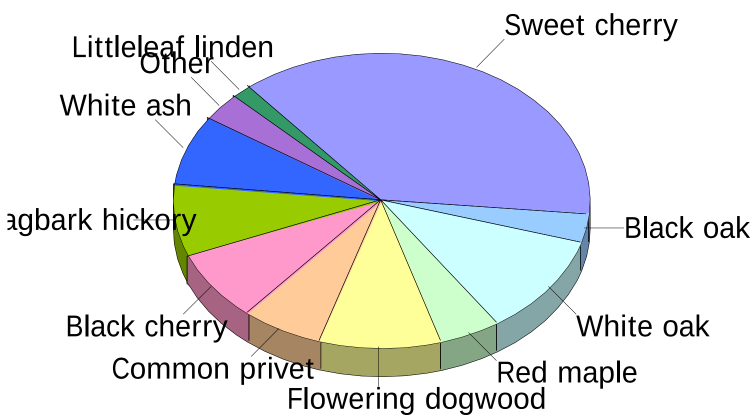


Figure 1. Tree species composition in Virginia Tech

The overall tree density in Virginia Tech is 320 trees / acre (see Appendix III for comparable values from other cities). For stratified projects, the highest tree densities in Virginia Tech occur in Woods South followed by Woods North and (n/a).

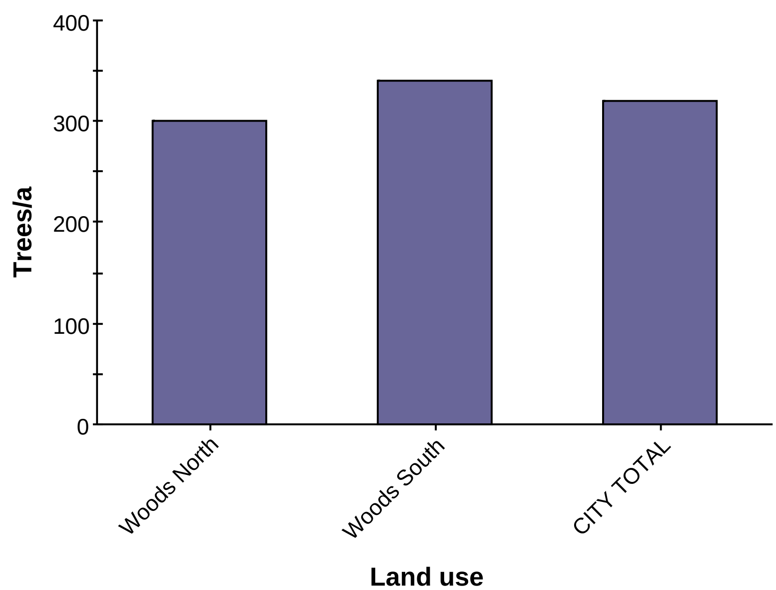


Figure 2. Number of trees/a in Virginia Tech by land use

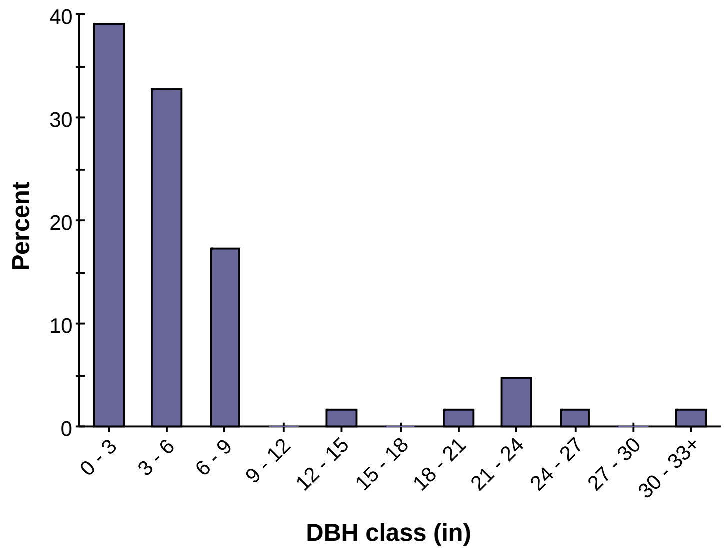


Figure 3. Percent of tree population by diameter class (DBH=stem diameter at 4.5 feet)

Urban forests are composed of a mix of native and exotic tree species. Thus, urban forests often have a tree diversity that is higher than surrounding native landscapes. An increased tree diversity can minimize the overall impact or destruction by a species-specific insect or disease, but it can also pose a risk to native plants if some of the exotic species are invasive plants that can potentially out-compete and displace native species. In Virginia Tech, about 53 percent of the trees are from species native to North America, while 53 percent are native to the state or district. Species exotic to Virginia make up 47 percent of the population. Most exotic tree species have an origin from N/A (37.5 percent of the species).

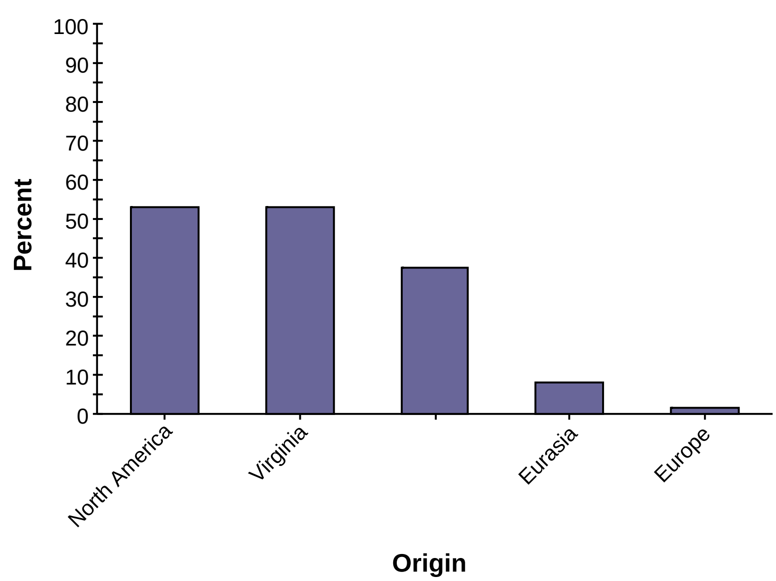


Figure 4. Percent of live trees by species origin

II. Urban Forest Cover and Leaf Area

Many tree benefits equate directly to the amount of healthy leaf surface area of the plant. In Virginia Tech, the three most dominant species in terms of leaf area are White oak, Sweet cherry, and Red maple. Trees cover about 80.5 percent of Virginia Tech, and shrubs cover 55.5 percent.

The 10 most important species are listed in the table below. Importance values (IV) are calculated as the sum of relative leaf area and relative composition.

Table 1. Most important species in Virginia Tech

Species Name	*Percent Population*	*Percent Leaf Area*	*IV*
White oak	10.9	56.0	67.0
Sweet cherry	37.5	18.7	56.2
Flowering dogwood	9.4	3.6	13.0
Shagbark hickory	7.8	3.6	11.4
White ash	7.8	3.6	11.4
Black cherry	7.8	2.7	10.5
Red maple	4.7	4.8	9.5
Common privet	6.2	1.5	7.7
Black oak	3.1	2.7	5.9
Norway maple	1.6	1.2	2.7

The two most dominant ground cover types are Duff/mulch (94.5 percent) and Bare Soil (3 percent).

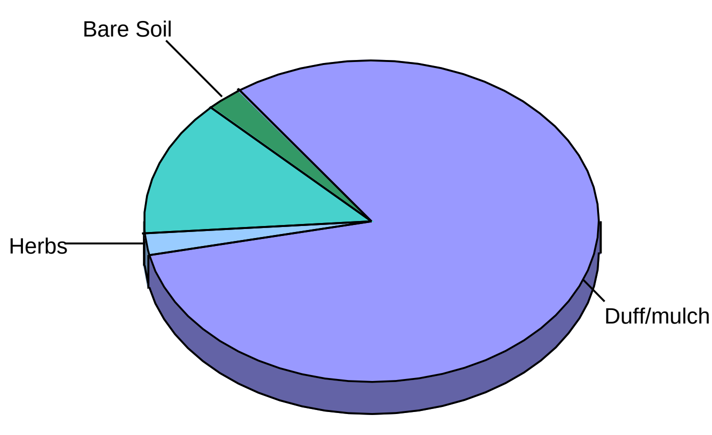


Figure 5. Percent ground cover in Virginia Tech

III. Air Pollution Removal by Urban Trees

Poor air quality is a common problem in many urban areas. It can lead to decreased human health, damage to landscape materials and ecosystem processes, and reduced visibility. The urban forest can help improve air quality by reducing air temperature, directly removing pollutants from the air, and reducing energy consumption in buildings, which consequently reduces air pollutant emissions from the power plants. Trees also emit volatile organic compounds that can contribute to ozone formation. However, integrative studies have revealed that an increase in tree cover leads to reduced ozone formation[1].

Pollution removal by trees and shrubs in Virginia Tech was estimated using field data and recent pollution and weather data available. Pollution removal was greatest for particulate matter to 10 microns. It is estimated that trees and shrubs remove 1 tons of air pollution (ozone (O3), carbon monoxide (CO), nitrogen dioxide (NO2), particulate matter less than 10 microns (PM10), and sulfur dioxide (SO2)) per year with an associated value of $5.19 thousand based on estimated national median externality costs associated with pollutants[2]. United States externality pollution values[26] will be substituted for international studies when pollutant values are not available.

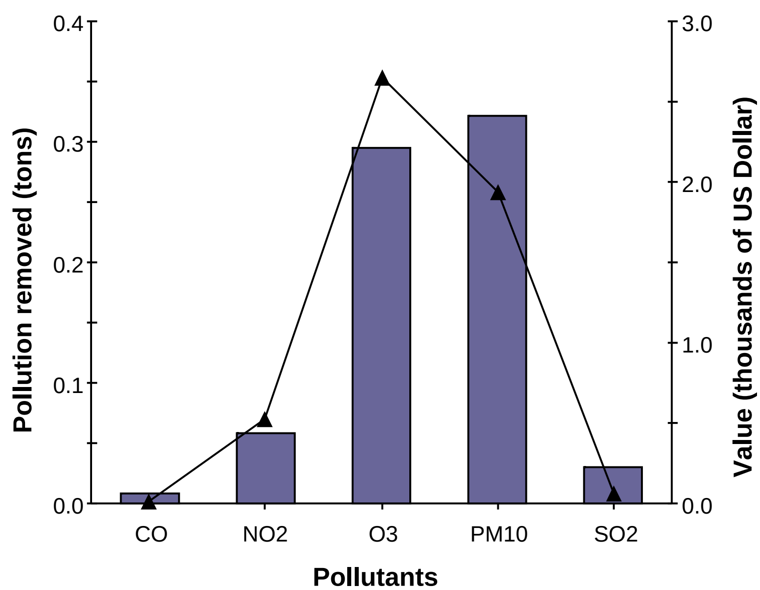


Figure 6. Pollution removal and associated value for trees in Virginia Tech (line graph is value)

IV. Carbon Storage and Sequestration

Climate change is an issue of global concern. Urban trees can help mitigate climate change by sequestering atmospheric carbon (from carbon dioxide) in tissue and by altering energy use in buildings, and consequently altering carbon dioxide emissions from fossil-fuel based power plants[3].

Trees reduce the amount of carbon in the atmosphere by sequestering carbon in new growth every year. The amount of carbon annually sequestered is increased with the size and health of the trees. The gross sequestration of Virginia Tech trees is about 21 tons of carbon per year with an associated value of $389. Net carbon sequestration in the urban forest is about 16 tons.

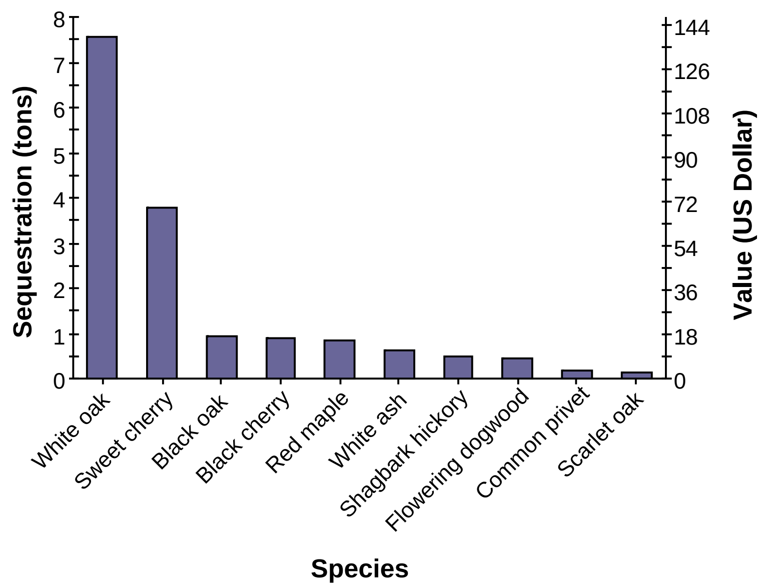


Figure 7. Carbon sequestration and value for species with greatest overall carbon sequestration in Virginia Tech

As trees grow they store more carbon as wood. As trees die and decay, they release much of the stored carbon back to the atmosphere. Thus, carbon storage is an indication of the amount of carbon that can be lost if trees are allowed to die and decompose. Trees in Virginia Tech are estimated to store 608 tons of carbon ($11.2 thousand). Of all the species sampled, White oak stores and sequesters the most carbon (approximately 84.5% of the total carbon stored and 47.2% of all sequestered carbon.)

V. Trees and Building Energy Use

Trees affect energy consumption by shading buildings, providing evaporative cooling, and blocking winter winds. Trees tend to reduce building energy consumption in the summer months and can either increase or decrease building energy use in the winter months, depending on the location of trees around the building. Estimates of tree effects on energy use are based on field measurements of tree distance and direction to space conditioned residential buildings[4].

Based on 2002 prices, trees in Virginia Tech are estimated to reduce energy-related costs from residential buildings by $0 annually. Trees also provide an additional $ in value[5] by reducing the amount of carbon released by fossil-fuel based power plants (a reduction of tons of carbon emissions).

Table 2. Annual energy savings due to trees near residential buildings. Note: negative numbers indicate an increased energy use or carbon emission.

	Heating	*Cooling*	*Total*
MBTU[1]		n/a	
MWH[2]			
Carbon avoided (t)			

[1]One million British Thermal Units
[2]Megawatt-hour

Table 3. Annual savings[1] ($) in residential energy expenditure during heating and cooling seasons. Note: negative numbers indicate a cost due to increased energy use or carbon emission.

	Heating	*Cooling*	*Total*
MBTU[2]		n/a	
MWH[3]			
Carbon avoided (t)			

[1]Based on state-wide energy costs for Virginia.
[2]One million British Thermal Units
[3]Megawatt-hour

VI. Structural and Functional Values

Urban forests have a structural value based on the trees themselves (e.g., the cost of having to replace a tree with a similar tree); they also have functional values (either positive or negative) based on the functions the trees perform.

The structural value of an urban forest tends to increase with a rise in the number and size of healthy trees [6]. Annual functional values also tend to increase with increased number and size of healthy trees, and are usually on the order of several million dollars per year. Through proper management, urban forest values can be increased; however, the values and benefits also can decrease as the amount of healthy tree cover declines.

Structural values:

- Structural value: $5.31 million
- Carbon storage: $11.2 thousand

Annual functional values:

- Carbon sequestration: $389
- Pollution removal: $5.19 thousand
- Lower energy costs and carbon emission reductions: $0 (Note: negative value indicates increased energy cost and carbon emission value)

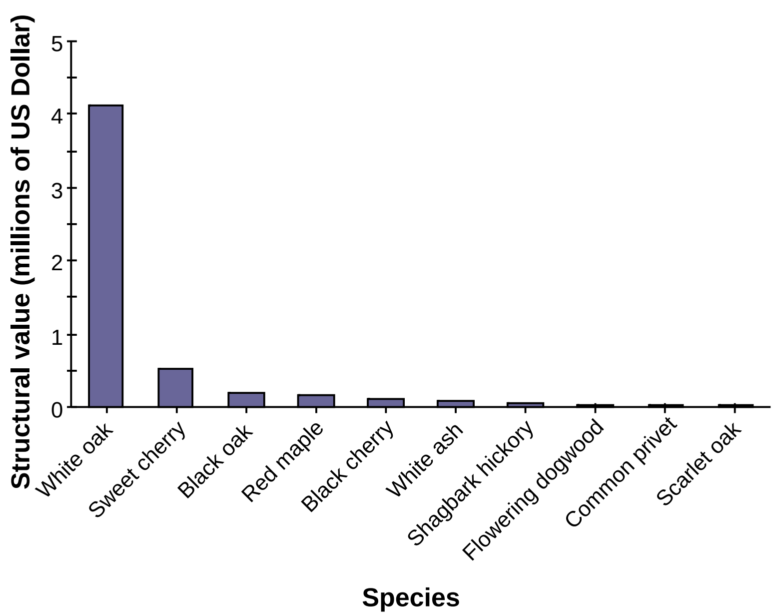


Figure 8. Structural value of the 10 most valuable tree species in Virginia Tech

VII. Potential Pest Impacts

Various insects and diseases can infest urban forests, potentially killing trees and reducing the health, value and sustainability of the urban forest. As pests tend to have differing tree hosts, the potential damage or risk of each pest will differ. Four exotic pests were analyzed for their potential impact: Asian longhorned beetle (ALB), gypsy moth (GM), emerald ash borer (EAB), and Dutch elm disease (DED).

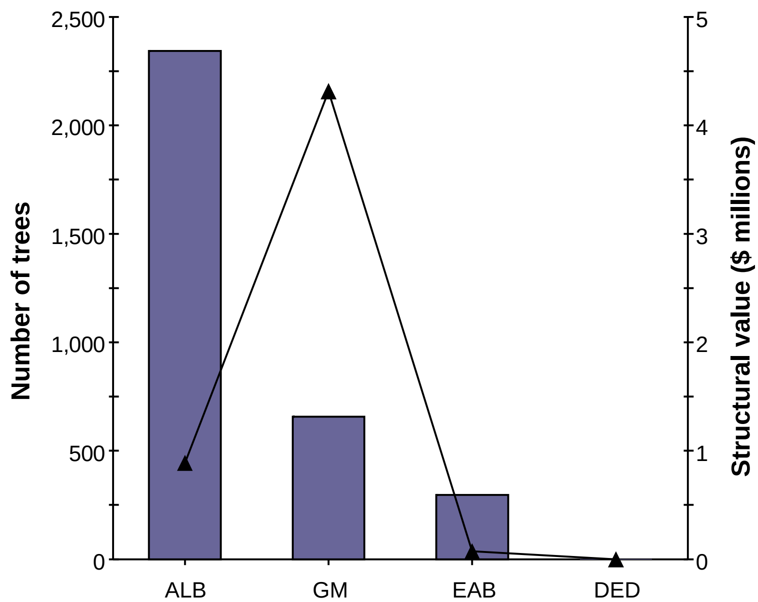


Figure 9. Number of susceptible Virginia Tech trees and structural value by pest (line graph is structural value)

The Asian longhorned beetle (ALB) [7] is an insect that bores into and kills a wide range of hardwood species. ALB poses a threat to 60.9 percent of the Virginia Tech urban forest, which represents a loss of $893 thousand in damage to the structure.

The gypsy moth (GM)[8] is a defoliator that feeds on many species causing widespread defoliation and tree death if outbreak conditions last several years. This pest threatens 17.2 percent of the population, which represents a loss of $4.31 million in structural value.

Emerald ash borer (EAB)[9] has killed thousands of ash trees in parts of the United States. EAB has the potential to affect 7.8 percent of the population ($74.7 thousand in structural damage).

American elm, one of the most important street trees in the twentieth century, has been devastated by the Dutch elm disease (DED)[10]. Since first reported in the 1930s, it has killed over 50 percent of the native elm population in the United States. Although some elm species have shown varying degrees of resistance, Virginia Tech could possibly lose 0 percent of its trees to this pest ($0 in structural value).

Appendix I. UFORE Model and Field Measurements

UFORE is designed to use standardized field data from randomly located plots and local hourly air pollution and meteorological data to quantify urban forest structure and its numerous effects [5], including:

- Urban forest structure (e.g., species composition, tree health, leaf area, etc.).
- Amount of pollution removed hourly by the urban forest, and its associated percent air quality improvement throughout a year. Pollution removal is calculated for ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide and particulate matter (<10 microns).
- Total carbon stored and net carbon annually sequestered by the urban forest.
- Effects of trees on building energy use and consequent effects on carbon dioxide emissions from power plants.
- Structural value of the forest, as well as the value for air pollution removal and carbon storage and sequestration.
- Potential impact of infestations by Asian longhorned beetles, emerald ash borers, gypsy moth, and Dutch elm disease.

In the field 0.10 acre plots were randomly distributed. Typically, all field data are collected during the leaf-on season to properly assess tree canopies. Within each plot, typical data collection (actual data collection may vary depending upon the user) includes land use, ground and tree cover, individual tree attributes of species, stem diameter, height, crown width, crown canopy missing and dieback, and distance and direction to residential buildings[11,26].

To calculate current carbon storage, biomass for each tree was calculated using equations from the literature and measured tree data. Open-grown, maintained trees tend to have less biomass than predicted by forest-derived biomass equations[12]. To adjust for this difference, biomass results for open-grown urban trees were multiplied by 0.8. No adjustment was made for trees found in natural stand conditions. Tree dry-weight biomass was converted to stored carbon by multiplying by 0.5.

To estimate the gross amount of carbon sequestered annually, average diameter growth from the appropriate genera and diameter class and tree condition was added to the existing tree diameter (year x) to estimate tree diameter and carbon storage in year x+1.

Air pollution removal estimates are derived from calculated hourly tree-canopy resistances for ozone, and sulfur and nitrogen dioxides based on a hybrid of big-leaf and multi-layer canopy deposition models[13,14]. As the removal of carbon monoxide and particulate matter by vegetation is not directly related to transpiration, removal rates (deposition velocities) for these pollutants were based on average measured values from the literature[15,16] that were adjusted depending on leaf phenology and leaf area. Particulate removal incorporated a 50 percent resuspension rate of particles back to the atmosphere[17]. Recent updates (2011) to air quality modeling are based on improved leaf area index simulations, weather and pollution processing and interpolation, and updated pollutant monetary values[27,28,29].

If appropriate field data were collected, seasonal effects of trees on residential building energy use were calculated based on procedures described in the literature[4] using distance and direction of trees from residential structures, tree height and tree condition data.

Structural values were based on valuation procedures of the Council of Tree and Landscape Appraisers, which uses tree species, diameter, condition and location information[18].

Appendix II. Relative Tree Effects

The urban forest in Virginia Tech provides benefits that include carbon storage and sequestration, and air pollutant removal. To estimate the relative value of these benefits, tree benefits were compared to estimates of average municipal carbon emissions[19], average passenger automobile emissions[20], and average household emissions[21].

Carbon storage is equivalent to:
• Amount of carbon emitted in Virginia Tech in 1 days
• Annual carbon (C) emissions from 365 automobiles
• Annual C emissions from 183 single-family houses

Carbon monoxide removal is equivalent to:
• Annual carbon monoxide emissions from automobiles
• Annual carbon monoxide emissions from single-family houses

Nitrogen dioxide removal is equivalent to:
• Annual nitrogen dioxide emissions from 4 automobiles
• Annual nitrogen dioxide emissions from 2 single-family houses

Sulfur dioxide removal is equivalent to:
• Annual sulfur dioxide emissions from 44 automobiles
• Annual sulfur dioxide emissions from 1 single-family houses

Particulate matter less than 10 micron (PM10) removal is equivalent to:
• Annual PM10 emissions from 859 automobiles
• Annual PM10 emissions from 83 single-family houses

Annual carbon sequestration is equivalent to:
• Amount of carbon emitted in Virginia Tech in days
• Annual C emissions from automobiles
• Annual C emissions from single-family houses

Note: estimates above are partially based on the user-supplied information on human population total for study area

Appendix III. Comparison of Urban Forests

A common question asked is, "How does this city compare to other cities?" Although comparison among cities should be made with caution as there are many attributes of a city that affect urban forest structure and functions, summary data are provided from other cities analyzed using the UFORE model.

I. City totals for trees

City	*% Tree Cover*	*Number of trees*	*Carbon storage (tons)*	*Carbon Sequestration (tons/yr)*	*Pollution removal (tons/yr)*	*Pollution Value (USD)*
Calgary, Canada	7.2	11,889,000	445,000	21,422	326	1,611,000
Atlanta, GA	36.8	9,415,000	1,345,000	46,433	1,662	2,534,000
Toronto, Canada	20.5	7,542,000	992,000	40,345	1,212	6,105,000
New York, NY	21.0	5,212,000	1,351,000	42,283	1,677	8,071,000
Baltimore, MD	21.0	2,627,000	596,000	16,127	430	2,129,000
Philadelphia, PA	15.7	2,113,000	530,000	16,115	576	2,826,000
Washington, DC	28.6	1,928,000	523,000	16,148	418	1,956,000
Boston, MA	22.3	1,183,000	319,000	10,509	284	1,426,000
Woodbridge, NJ	29.5	986,000	160,000	5561.00	210	1,037,000
Minneapolis, MN	26.5	979,000	250,000	8,895	305	1,527,000
Syracuse, NY	23.1	876,000	173,000	5,425	109	268,000
Morgantown, WV	35.9	661,000	94,000	2,940	66	311,000
Moorestown, NJ	28.0	583,000	117,000	3,758	118	576,000
Jersey City, NJ	11.5	136,000	21,000	890	41	196,000
Freehold, NJ	34.4	48,000	20,000	545	21	133,000

II. Per acre values of tree effects

City	*No. of trees*	*Carbon storage (tons)*	*Carbon sequestration (lbs/yr)*	*Pollution removal (lbs/yr)*	*Pollution Value (USD)*
Calgary, Canada	66.7	2.5	0.120	3.6	9.0
Atlanta, GA	111.6	15.9	0.550	39.4	30.0
Toronto, Canada	48.3	6.4	0.258	15.6	39.1
New York, NY	26.4	6.8	0.214	17.0	40.9
Baltimore, MD	50.8	11.5	0.312	16.6	41.2
Philadelphia, PA	25.0	6.3	0.190	13.6	33.5
Washington, DC	49.0	13.3	0.410	21.2	49.7
Boston, MA	33.5	9.0	0.297	16.0	40.4
Woodbridge, NJ	66.5	10.8	0.375	28.4	70.0
Minneapolis, MN	26.2	6.7	0.238	16.4	40.9
Syracuse, NY	54.5	10.8	0.338	13.6	16.7
Morgantown, WV	119.7	17.0	0.532	23.8	56.3
Moorestown, NJ	62.0	12.5	0.400	25.2	61.3
Jersey City, NJ	14.3	2.2	0.094	8.6	20.7
Freehold, NJ	38.5	16.0	0.437	33.6	106.6

Appendix IV. General Recommendations for Air Quality Improvement

Urban vegetation can directly and indirectly affect local and regional air quality by altering the urban atmosphere environment. Four main ways that urban trees affect air quality are[22]:

- Temperature reduction and other microclimate effects
- Removal of air pollutants
- Emission of volatile organic compounds (VOC) and tree maintenance emissions
- Energy effects on buildings

The cumulative and interactive effects of trees on climate, pollution removal, and VOC and power plant emissions determine the impact of trees on air pollution. Cumulative studies involving urban tree impacts on ozone have revealed that increased urban canopy cover, particularly with low VOC emitting species, leads to reduced ozone concentrations in cities[23]. Local urban management decisions also can help improve air quality.

Urban forest management strategies to help improve air quality include[24]:

Strategy	***Result***
Increase the number of healthy trees	Increase pollution removal
Sustain existing tree cover	Maintain pollution removal levels
Maximize use of low VOC-emitting trees	Reduces ozone and carbon monoxide formation
Sustain large, healthy trees	Large trees have greatest per-tree effects
Use long-lived trees	Reduce long-term pollutant emissions from planting and removal
Use low maintenance trees	Reduce pollutants emissions from maintenance activities
Reduce fossil fuel use in maintaining vegetation	Reduce pollutant emissions
Plant trees in energy conserving locations	Reduce pollutant emissions from power plants
Plant trees to shade parked cars	Reduce vehicular VOC emissions
Supply ample water to vegetation	Enhance pollution removal and temperature reduction
Plant trees in polluted or heavily populated areas	Maximizes tree air quality benefits
Avoid pollutant-sensitive species	Improve tree health
Utilize evergreen trees for particulate matter	Year-round removal of particles

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Average annual passenger automobile emissions per vehicle were based on dividing total 2002 pollutant emissions from light-duty gas vehicles by total number of passenger cars in 2002 (National Transportation Statistics http://www.bts.gov/publications/national_transportation_statistics/2004/).

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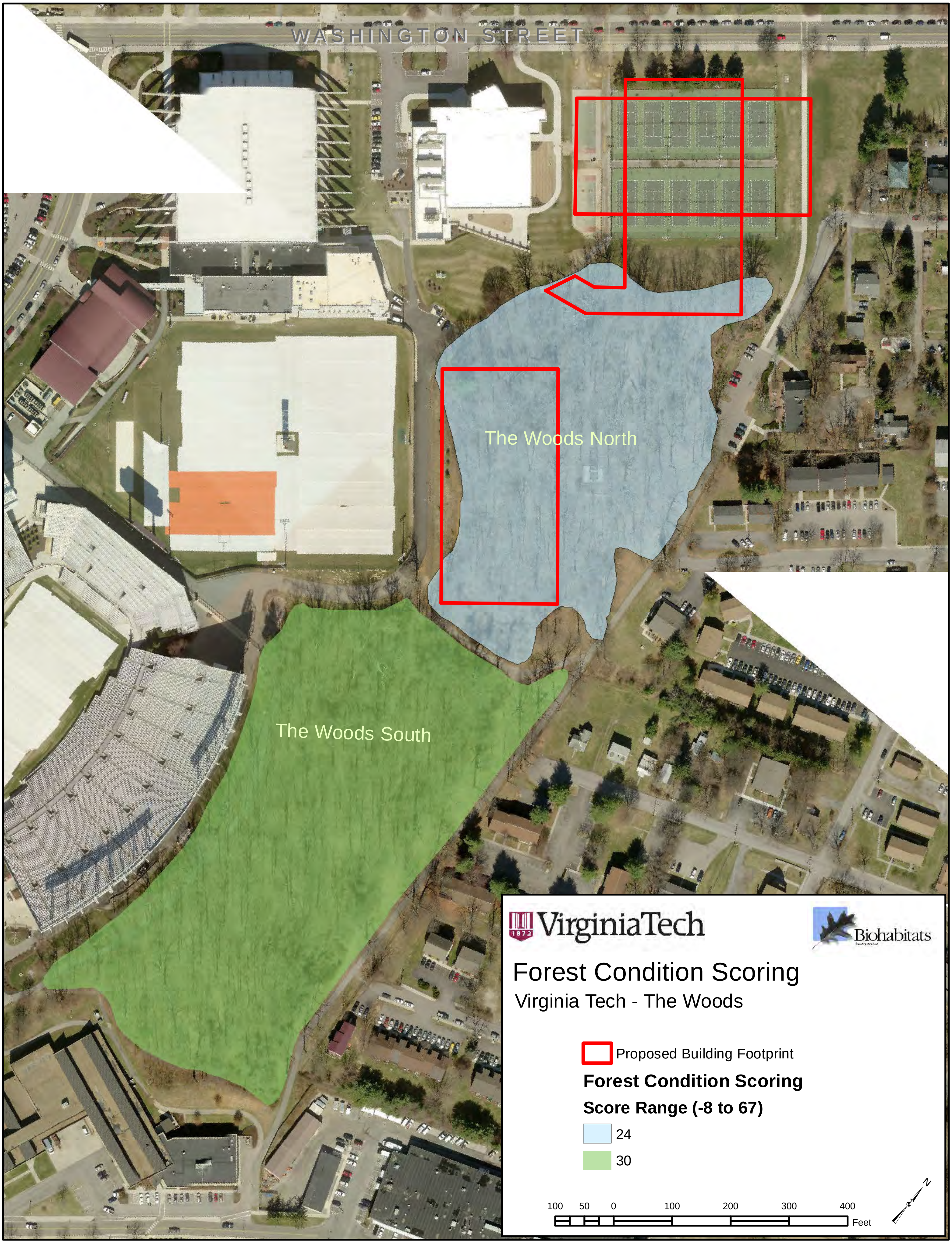
APPENDIX M

FOREST CONDITION SCORING METRICS

	North	South
Date	3/13/2012	3/13/2012
Evaluator	BWS/MWT	BWS/MWT
No Species	3	3
Succession	5	5
Canopy Cover	5	5
Understory	3	5
Herbaceous	3	1
Native Regeneration	5	5
Significant Trees	5	5
Forest Interior	0	0
Invasive Canopy	-1	-1
Invasive Understory	-5	-3
Invasive Herbaceous	-5	-1
Disease/Infestation	0	0
Proximity-forest	1	1
Proximity-wetland	1	1
Proximity -RTE	1	1
Proximity-erosive soil	1	1
Proximity-hydric soil	1	1
Proximity-floodplain	1	1
Notes	snags	snags
Latitude	37.22251686	37.21942459
Longitude	-80.41670389	-80.41618895
Score	**24**	**30**

APPENDIX N

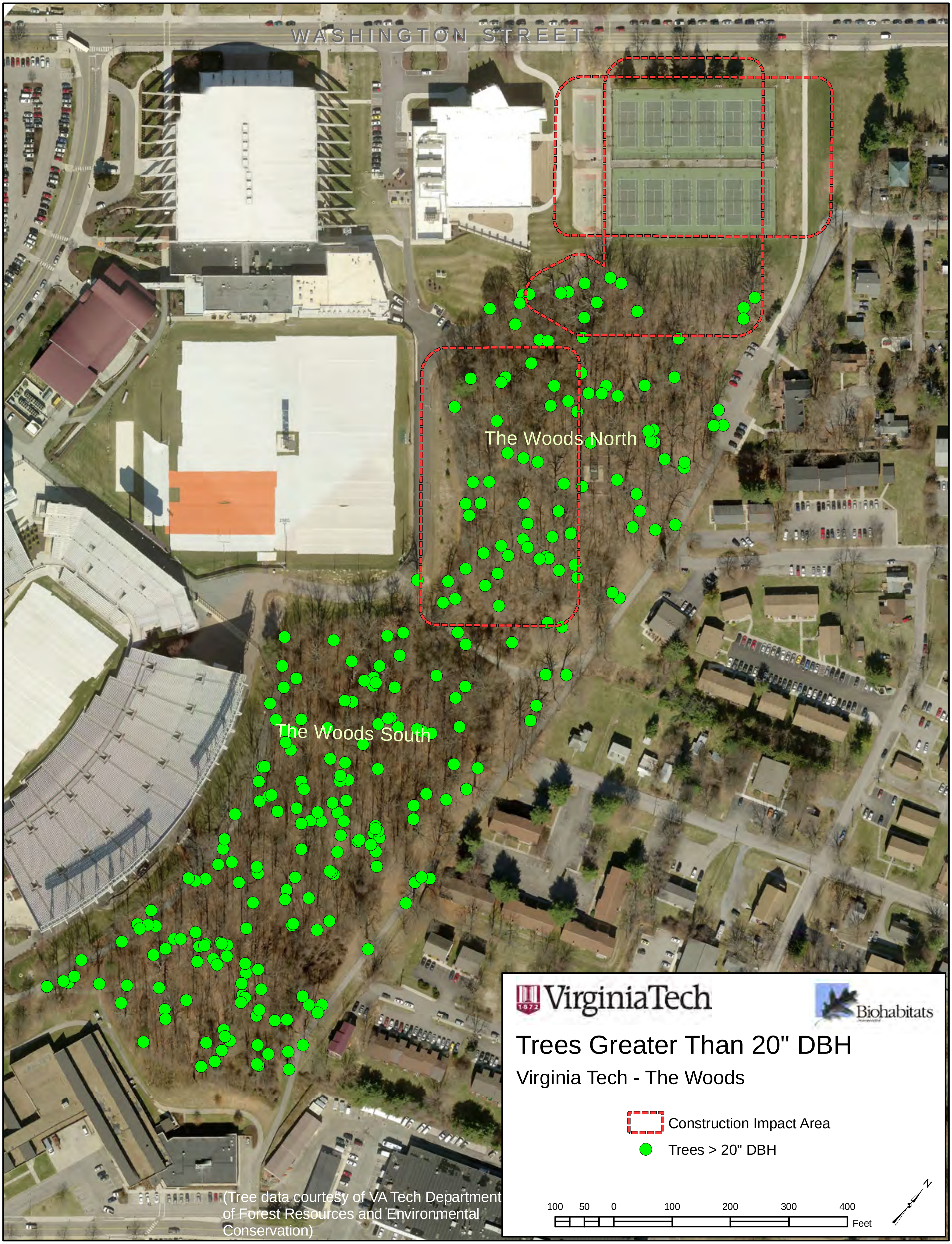
FOREST CONDITION SCORES



WASHINGTON STREET
The Woods North
The Woods South
VirginiaTech
Biohabitats
Forest Condition Scoring
Virginia Tech - The Woods
Proposed Building Footprint
Forest Condition Scoring
Score Range (-8 to 67)
24
30
100 50 0 100 200 300 400
Feet
N

APPENDIX O

TREES GREATER THAN 20" IN DIAMETER AT BREAST HEIGHT


WASHINGTON STREET
The Woods North
The Woods South
VirginiaTech
1872
Biohabitats
Trees Greater Than 20" DBH
Virginia Tech - The Woods
Construction Impact Area
Trees > 20" DBH
100 50 0 100 200 300 400
Feet
N
(Tree data courtesy of VA Tech Department of Forest Resources and Environmental Conservation)

APPENDIX P

U.S. FISH AND WILDLIFE SERVICE NATURAL RESOURCES OF CONCERN

U.S. Fish and Wildlife Service

Natural Resources of Concern

This resource list is to be used for planning purposes only — it is not an official species-list.

Endangered Species Act species-list information for your project is available online and listed below for the following FWS Field Offices:

VIRGINIA ECOLOGICAL SERVICES FIELD OFFICE
6669 SHORT LANE
GLOUCESTER, VA 23061
(804) 693-6694
http://www.fws.gov/northeast/virginiafield/

Project Name:

Stadium Woods

Project Counties:

Montgomery, VA

Project Type:

Development

Endangered Species Act Species-list

There are a total of **6** species in your species-list

Species that may be affected by your project:

Fishes				
Roanoke logperch (*Percina rex*)	Endangered	species info		Virginia Ecological Services Field Office
Flowering Plants				

Natural Resources of Concern

Smooth coneflower (*Echinacea laevigata*)	Endangered	species info		Virginia Ecological Services Field Office
Virginia spiraea (*Spiraea virginiana*)	Threatened	species info		Virginia Ecological Services Field Office
Insects				
Mitchell's Satyr Butterfly (*Neonympha mitchellii mitchellii*)	Endangered	species info		Virginia Ecological Services Field Office
Mammals				
Indiana bat (*Myotis sodalis*)	Endangered	species info		Virginia Ecological Services Field Office
Virginia Big-Eared bat (*Corynorhinus townsendii virginianus*)	Endangered	species info		Virginia Ecological Services Field Office

FWS National Wildlife Refuges

There are no refuges found within the vicinity of your project.

FWS Migratory Birds

Not yet available through IPaC.

FWS Delineated Wetlands

Not yet available through IPaC.

APPENDIX Q

VIRGINIA DEPARTMENT OF CONSERVATION AND RECREATION NATURAL HERITAGE RESOURCES

Natural Heritage Resources by County

Your Search Criteria:
Montgomery County(ies)
Search run: 04-06-2012

Click highlighted scientific names below to go to NatureServe report. Search Menu

Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Last Year Observed
Montgomery						
AMPHIBIANS						
Cryptobranchus alleganiensis	Hellbender	G3G4	S2S3			1979
BIRDS						
Cistothorus platensis	Sedge Wren	G5	S1B,S1S2N			2003
BIVALVIA (MUSSELS)						
Lasmigona subviridis	Green Floater	G3	S2		LT	1981
COLEOPTERA (BEETLES)						
Atheta annexa	A Rove Beetle	G4	S2			1981
Pseudanophthalmus pusio	A Cave Beetle	G2G3	S1S2	SOC		1981
COLLEMBOLA (SPRINGTAILS)						
Pygmarrhopalites clarus	A Cave Springtail	G4	S1			1981
COMMUNITIES						
Juniperus virginiana / Schizachyrium scoparium - Andropogon gerardii - Carex eburnea Wooded Herbaceous Vegetation	Limestone / Dolomite Barren (Ridge and Valley Hillslope Type)	G2	S1S2			1995
Packera aurea - Carex interior - Carex hystericina - Parnassia grandifolia Herbaceous Vegetation	Ridge and Valley Calcareous Sedge Fen / Seep	G2	S1			2007
Pinus virginiana - Quercus montana - Carya glabra / Phlox subulata - Packera antennariifolia Woodland	Central Appalachian Shale Barren (Southern Type)	G3G4	S3S4			1988
Quercus muhlenbergii - Acer (nigrum, saccharum) / Ostrya virginiana / Erigeron pulchellus - Packera obovata Forest	Appalachian Sugar Maple - Chinkapin Oak Dry Calcareous Forest	G4?	S4?			2008

Quercus muhlenbergii - Juniperus virginiana / Packera plattensis - Parthenium auriculatum - Schizachyrium scoparium Woodland	Ridge and Valley Dolomite Woodland	G2	S2			2010
Quercus rubra - Quercus (montana, alba) - Carya ovalis / Carex pensylvanica - (Calamagrostis porteri) Forest	Central Appalachian Montane Oak - Hickory Forest (Acidic Type)	G3G4	S3S4			1994
Typha latifolia - Caltha palustris Herbaceous Vegetation	Ridge and Valley Calcareous Spring Marsh (Broad-Leaved Cattail - Marsh Marigold Type)	G1	S1			2001
CRUSTACEA (AMPHIPODS ISOPODS & DECAPODS)						
Caecidotea vandeli	Vandel's Cave Isopod	G3G4	S2			1969
Stygobromus fergusoni	Montgomery County Cave Amphipod	G2G3	S1	SOC		1969
DIPLOPODA (MILLIPEDES)						
Pseudotremia cavernarum	Ellett Valley Pseudotremia Millipede	G2G3	S1	SOC	LT	1994
DIPLURA (DIPLURANS)						
Litocampa sp. 3	A Cave Dipluran	G2	S2	SOC		1971
EPHEMEROPTERA (MAYFLIES)						
Ephemerella berneri	Berner's Ephemerella Mayfly	G4	S1S3			1980
FISH						
Noturus gilberti	Orangefin Madtom	G2	S2	SOC	LT	2004
Percina rex	Roanoke Logperch	G1G2	S1S2	LE	LE	2010
Phenacobius teretulus	Kanawha Minnow	G3G4	S2S3			1981
LEPIDOPTERA (BUTTERFLIES & MOTHS)						
Calephelis borealis	Northern Metalmark	G3G4	S2S3			2004
Callophrys irus	Frosted Elfin	G3	S2?			1974
Catocala herodias gerhardi	Pine Barrens Underwing	G3T3	S2S3			1985
Catocala marmorata	Marbled Underwing	G3G4	S2			1991
Catocala messalina	Messalina Underwing	G4	SH			ND
Dichagyris grotei	A Noctuid Moth	G4	S1S3			2000
Erora laeta	Early Hairstreak	GU	S2			1969
Erynnis martialis	Mottled Duskywing	G3	S1S3			1974
Erynnis persius persius	Persius Duskywing	G5T1T3	S1	SOC		1974
Euchlaena milnei	Milne's Euchlaena Moth	G2G4	S2			2003

Pyrgus centaureae wyandot	Appalachian Grizzled Skipper	G1G2Q	S1	SOC	LT	1975
Speyeria idalia	Regal Fritillary	G3	S1			2000
MAMMALS						
Myotis sodalis	Indiana Bat	G2	S1	LE	LE	1947
ODONATA (DRAGONFLIES & DAMSELFLIES)						
Lanthus parvulus	Northern Pygmy Clubtail	G4	S2			1979
Lestes disjunctus	Common Spreadwing	G5	S2			1948
Stylurus laurae	Laura's Clubtail	G4	S2			1974
Sympetrum corruptum	Variegated Meadowhawk	G5	S1			1977
PLECOPTERA (STONEFLIES)						
Allocapnia simmonsi	Spatulate Snowfly	G3	S1S2			2001
REPTILES						
Plestiodon anthracinus	Coal Skink	G5	S2S3			2004
SIGNIFICANT CAVES						
Significant cave	Significant Cave	G3	SNR			1985
VASCULAR PLANTS						
Agalinis auriculata	Earleaf Foxglove	G3	S1			1940
Anemone canadensis	Canada Anemone	G5	S1			1986
Astragalus neglectus	Cooper's Milkvetch	G4	S2			2010
Buckleya distichophylla	Piratebush	G3	S2			2002
Carex cristatella	Crested Sedge	G5	S2			1988
Carex interior	Inland Sedge	G5	S1			2003
Carex juniperorum	a sedge	G3	S1		LE	2009
Carex schweinitzii	Schweinitz's Sedge	G3G4	S1			2009
Cheilanthes eatonii	Chestnut Lipfern	G5?	S2			2008
Clematis addisonii	Addison's Leatherflower	G2	S2	SOC		2008
Crataegus succulenta	Fleshy Hawthorn	G5	S1			2003
Cypripedium candidum	Small White Ladies-slipper	G4	S1			2007
Cystopteris tennesseensis	Tennessee Bladderfern	G5	S1			1982
Desmodium cuspidatum var. cuspidatum	Toothed Tick-trefoil	G5T5?	S2			2007
Echinacea laevigata	Smooth Coneflower	G2G3	S2	LE	LT	2010
Eleocharis compressa	Flat-stemmed Spike-rush	G4	S2			2003
Eleocharis intermedia	Matted Spikerush	G5	S1			1997
Eupatorium maculatum var. maculatum	Spotted Joe-pye Weed	G5T5	S2			1980

Euphorbia purpurea	Glade Spurge	G3	S2		2003
Gentianella quinquefolia ssp. occidentalis	Stiff Gentian	G5T4T5	S1?		2003
Gentianopsis crinita	Fringed Gentian	G5	S1		1984
Hasteola suaveolens	Sweet-scented Indian-plantain	G4	S2		1991
Juncus articulatus	Jointed Rush	G5	S1S2		1998
Juncus brachycephalus	Small-head Rush	G5	S2		2001
Juncus torreyi	Torrey's Rush	G5	S2		1973
Lemna trisulca	Star Duckweed	G5	S1		1972
Liparis loeselii	Loesel's Twayblade	G5	S2		1996
Lysimachia quadriflora	Four-flowered Loosestrife	G5?	S1		1981
Oligoneuron rigidum var. rigidum	Stiff Goldenrod	G5T5	S2		1993
Parnassia grandifolia	Large-leaved Grass-of-parnassus	G3	S2		2007
Paxistima canbyi	Canby's Mountain-lover	G2	S2	SOC	2003
Phlox buckleyi	Sword-leaved Phlox	G2	S2	SOC	1990
Poa saltuensis	A Bluegrass	G5	S2		1987
Quercus prinoides	Dwarf Chinquapin Oak	G5	S1		1936
Rhamnus alnifolia	Alderleaf Buckthorn	G5	S1		2007
Rhynchospora capillacea	Capillary Beakrush	G4	S1		1937
Rosa setigera	Prairie Rose	G5	S1		2007
Rudbeckia triloba var. pinnatiloba	Pinnate-lobed Black-eyed Susan	G5T3	S1		1993
Scleria verticillata	Whorled Nutrush	G5	S2		1993
Smilax ecirrata	Upright Greenbrier	G5?	S1		2001
Spiranthes lucida	Shining Ladies'-tresses	G5	S1		1996
Spiranthes magnicamporum	Great Plains Ladies'-tresses	G4	S1		2003
Sporobolus compositus var. compositus	Longleaf Dropseed	G5T5	S1		2002
Sporobolus neglectus	Small Dropseed	G5	S2		1992
Vicia americana ssp. americana	American Purple Vetch	G5T5	S1S2		1971
Viola walteri	Prostrate Blue Violet	G4G5	S2		2003

Note: On-line queries provide basic information from DCR's databases at the time of the request. They are NOT to be substituted for a project review or for on-site surveys required for environmental assessments of specific project areas.

Need Additional Information? For more detailed information on locations of Natural Heritage Resources submit an information request.

Want to Contribute? If you have information on locations of natural heritage resources, please fill out and submit a rare species sighting form

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Return to the Database Search page

APPENDIX R

THE WOODS BIRD SPECIES

Vultures, Hawks, Falcons, and Allies

Turkey Vulture
Red-tailed Hawk
Black Vulture
American Kestrel
Sharp-shinned Hawk
Cooper's Hawk
Broad-winged Hawk
Red-shouldered Hawk
Osprey
Bald Eagle
Northern Harrier
Golden Eagle
Merlin
Peregrine Falcon

Pigeons and Doves

Mourning Dove
Rock Pigeon
Eurasian Collared-Dove

Owls

Eastern Screech-Owl
Great Horned Owl
Barred Owl

Woodpeckers

Downy Woodpecker
Red-bellied Woodpecker
Pileated Woodpecker
Northern Flicker
Hairy Woodpecker
Yellow-bellied Sapsucker
Red-headed Woodpecker

Tyrant Flycatchers

Eastern Phoebe
Eastern Wood-Pewee
Great Crested Flycatcher
Eastern Kingbird
Acadian Flycatcher
Least Flycatcher

Vireos

Red-eyed Vireo
Blue-headed Vireo
Yellow-throated Vireo
Warbling Vireo
White-eyed Vireo

Jays, Crows, Ravens

American Crow
Blue Jay
Common Raven

Swifts, Martins, and Swallows

Tree Swallow
Barn Swallow
Chimney Swift
Northern Rough-winged Swallow
Purple Martin
Cliff Swallow

Chickadees, Titmice, Nuthatch, Creeper

Tufted Titmouse
Carolina Chickadee
White-breasted Nuthatch
Red-breasted Nuthatch
Brown Creeper

Wrens

Carolina Wren
House Wren
Winter Wren

Kinglets and Gnatcatcher

Blue-gray Gnatcatcher
Ruby-crowned Kinglet
Golden-crowned Kinglet

Thrushes

American Robin
Eastern Bluebird
Wood Thrush
Hermit Thrush
Veery
Swainson's Thrush

Catbirds, Mockingbirds, Thrashers

Northern Mockingbird
Gray Catbird
Brown Thrasher

Warblers

Yellow-rumped Warbler
American Redstart
Ovenbird
Black-and-white Warbler
Black-throated Green Warbler
Hooded Warbler
Common Yellowthroat
Chestnut-sided Warbler
Worm-eating Warbler
Pine Warbler
Black-throated Blue Warbler
Magnolia Warbler
Northern Parula
Cerulean Warbler
Blackburnian Warbler
Yellow Warbler
Canada Warbler
Tennessee Warbler
Yellow-breasted Chat
Kentucky Warbler
Blackpoll Warbler
Cape May Warbler
Palm Warbler
Prairie Warbler
Nashville Warbler
Bay-breasted Warbler
Yellow-throated Warbler
Blue-winged Warbler

Sparrows

Song Sparrow
Eastern Towhee
Dark-eyed Junco
White-throated Sparrow
Chipping Sparrow
Field Sparrow
White-crowned Sparrow
Fox Sparrow
Swamp Sparrow
Lincoln's Sparrow
American Tree Sparrow

Cardinals, Grosbeaks, and Allies

Northern Cardinal
Indigo Bunting
Scarlet Tanager
Rose-breasted Grosbeak
Blue Grosbeak

Blackbirds

Common Grackle
Red-winged Blackbird
Brown-headed Cowbird
Baltimore Oriole
Orchard Oriole
Rusty Blackbird

Finches

American Goldfinch
House Finch
Purple Finch
Pine Siskin

Cuckoos

Yellow-billed Cuckoo
Black-billed Cuckoo

Others

European Starling
Cedar Waxwing
House Sparrow
Ruby-throated Hummingbird
Killdeer
Wild Turkey
Ring-billed Gull
Ruffed Grouse
Common Nighthawk
Eastern Whip-poor-will
American Woodcock
Loggerhead Shrike

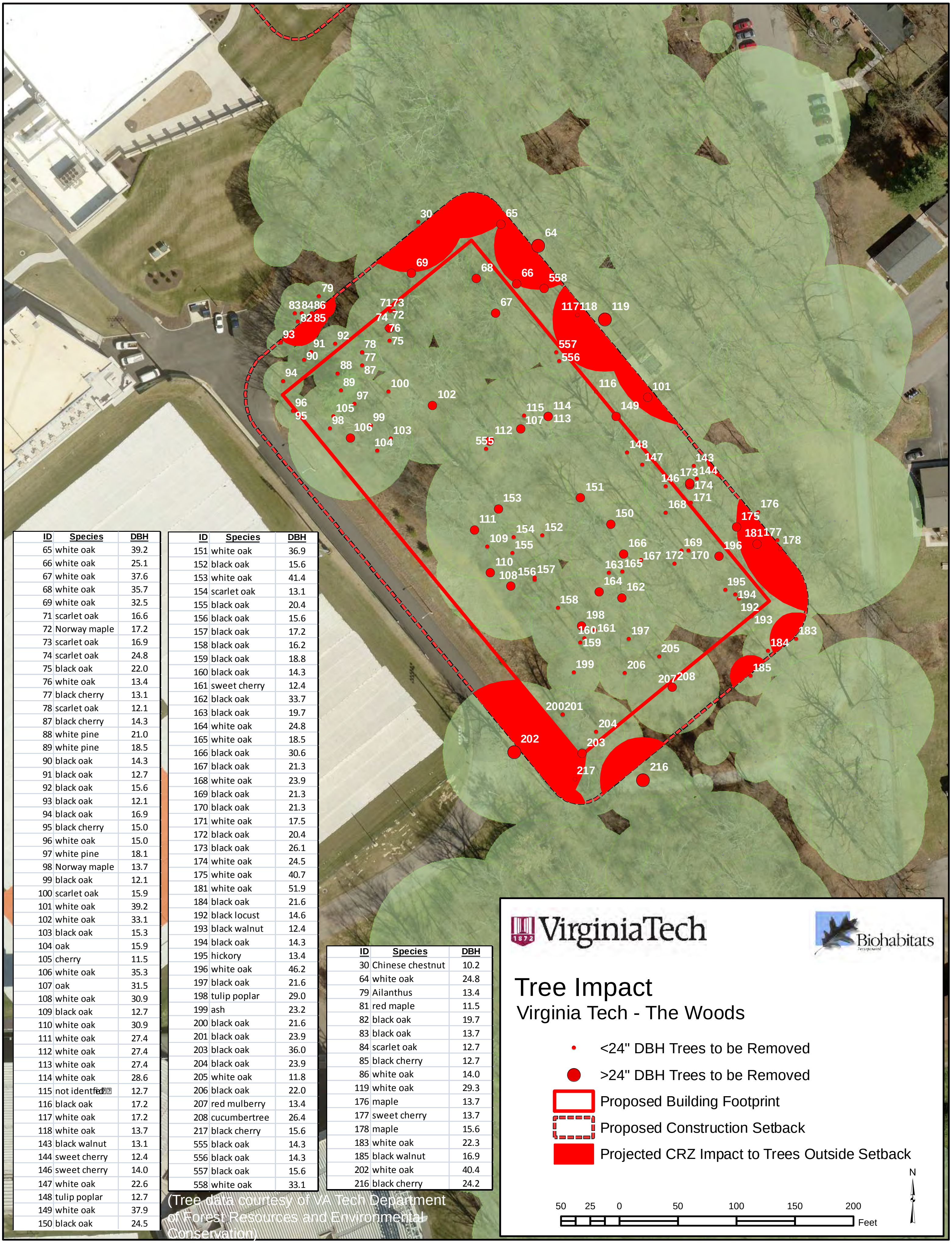
Additional Space for Nonlisted Species

Common Nighthawk

(J. Kirwan via M. Gart, personal communication, April 11, 2012)

APPENDIX S

CRITICAL ROOT ZONE IMPACTS



Tree Impact

Virginia Tech - The Woods

VirginiaTech

Biohabitats

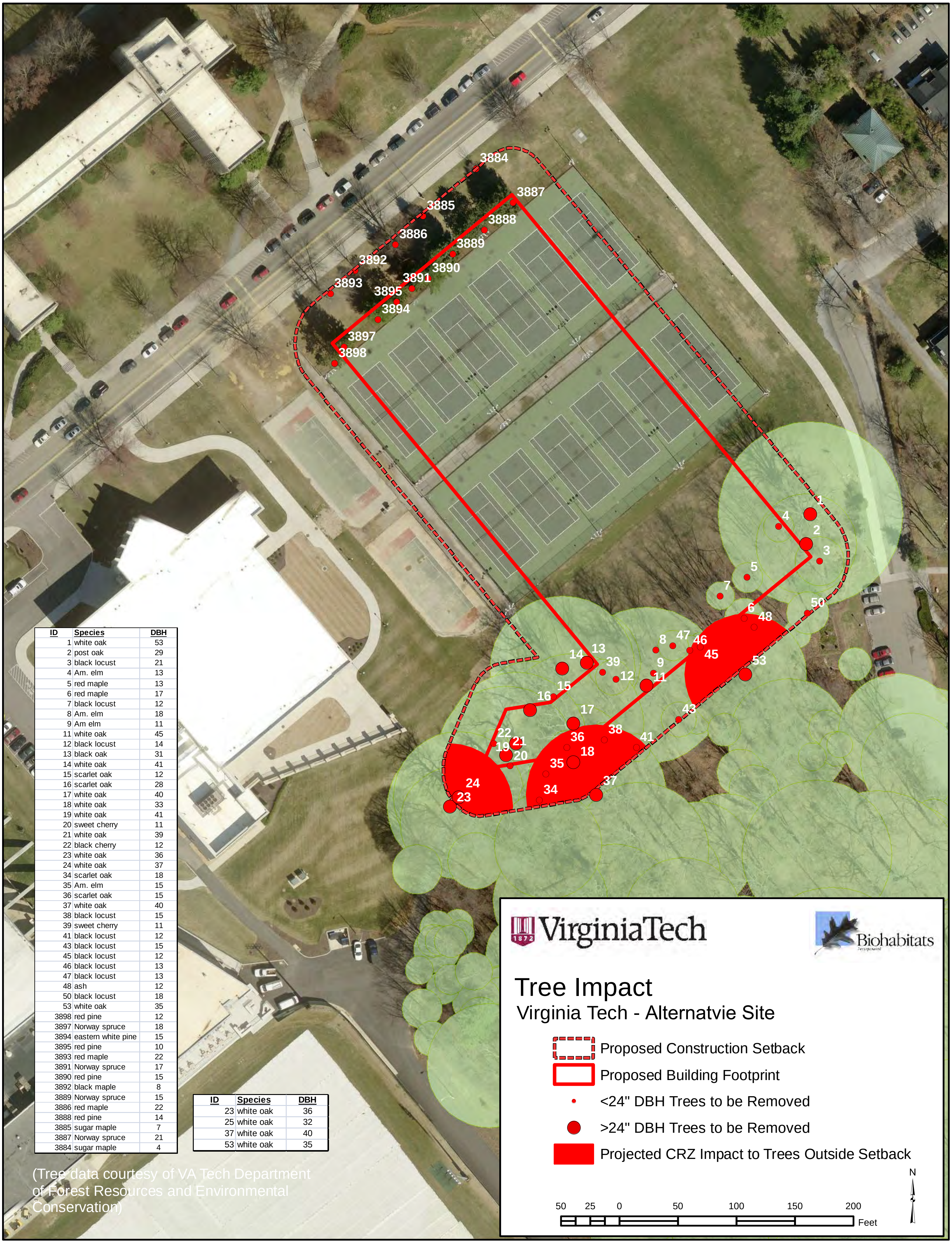
- <24" DBH Trees to be Removed
- >24" DBH Trees to be Removed
- Proposed Building Footprint
- Proposed Construction Setback
- Projected CRZ Impact to Trees Outside Setback

ID	Species	DBH
65	white oak	39.2
66	white oak	25.1
67	white oak	37.6
68	white oak	35.7
69	white oak	32.5
71	scarlet oak	16.6
72	Norway maple	17.2
73	scarlet oak	16.9
74	scarlet oak	24.8
75	black oak	22.0
76	white oak	13.4
77	black cherry	13.1
78	scarlet oak	12.1
87	black cherry	14.3
88	white pine	21.0
89	white pine	18.5
90	black oak	14.3
91	black oak	12.7
92	black oak	15.6
93	black oak	12.1
94	black oak	16.9
95	black cherry	15.0
96	white oak	15.0
97	white pine	18.1
98	Norway maple	13.7
99	black oak	12.1
100	scarlet oak	15.9
101	white oak	39.2
102	white oak	33.1
103	black oak	15.3
104	oak	15.9
105	cherry	11.5
106	white oak	35.3
107	oak	31.5
108	white oak	30.9
109	black oak	12.7
110	white oak	30.9
111	white oak	27.4
112	white oak	27.4
113	white oak	27.4
114	white oak	28.6
115	not identfied	12.7
116	black oak	17.2
117	white oak	17.2
118	white oak	13.7
143	black walnut	13.1
144	sweet cherry	12.4
146	sweet cherry	14.0
147	white oak	22.6
148	tulip poplar	12.7
149	white oak	37.9
150	black oak	24.5

ID	Species	DBH
151	white oak	36.9
152	black oak	15.6
153	white oak	41.4
154	scarlet oak	13.1
155	black oak	20.4
156	black oak	15.6
157	black oak	17.2
158	black oak	16.2
159	black oak	18.8
160	black oak	14.3
161	sweet cherry	12.4
162	black oak	33.7
163	black oak	19.7
164	white oak	24.8
165	white oak	18.5
166	black oak	30.6
167	black oak	21.3
168	white oak	23.9
169	black oak	21.3
170	black oak	21.3
171	white oak	17.5
172	black oak	20.4
173	black oak	26.1
174	white oak	24.5
175	white oak	40.7
181	white oak	51.9
184	black oak	21.6
192	black locust	14.6
193	black walnut	12.4
194	black oak	14.3
195	hickory	13.4
196	white oak	46.2
197	black oak	21.6
198	tulip poplar	29.0
199	ash	23.2
200	black oak	21.6
201	black oak	23.9
203	black oak	36.0
204	black oak	23.9
205	white oak	11.8
206	black oak	22.0
207	red mulberry	13.4
208	cucumbertree	26.4
217	black cherry	15.6
555	black oak	14.3
556	black oak	14.3
557	black oak	15.6
558	white oak	33.1

ID	Species	DBH
30	Chinese chestnut	10.2
64	white oak	24.8
79	Ailanthus	13.4
81	red maple	11.5
82	black oak	19.7
83	black oak	13.7
84	scarlet oak	12.7
85	black cherry	12.7
86	white oak	14.0
119	white oak	29.3
176	maple	13.7
177	sweet cherry	13.7
178	maple	15.6
183	white oak	22.3
185	black walnut	16.9
202	white oak	40.4
216	black cherry	24.2

(Tree data courtesy of VA Tech Department of Forest Resources and Environmental Conservation)



ID	Species	DBH
1	white oak	53
2	post oak	29
3	black locust	21
4	Am. elm	13
5	red maple	13
6	red maple	17
7	black locust	12
8	Am. elm	18
9	Am elm	11
11	white oak	45
12	black locust	14
13	black oak	31
14	white oak	41
15	scarlet oak	12
16	scarlet oak	28
17	white oak	40
18	white oak	33
19	white oak	41
20	sweet cherry	11
21	white oak	39
22	black cherry	12
23	white oak	36
24	white oak	37
34	scarlet oak	18
35	Am. elm	15
36	scarlet oak	15
37	white oak	40
38	black locust	15
39	sweet cherry	11
41	black locust	12
43	black locust	15
45	black locust	12
46	black locust	13
47	black locust	13
48	ash	12
50	black locust	18
53	white oak	35
3898	red pine	12
3897	Norway spruce	18
3894	eastern white pine	15
3895	red pine	10
3893	red maple	22
3891	Norway spruce	17
3890	red pine	15
3892	black maple	8
3889	Norway spruce	15
3886	red maple	22
3888	red pine	14
3885	sugar maple	7
3887	Norway spruce	21
3884	sugar maple	4

ID	Species	DBH
23	white oak	36
25	white oak	32
37	white oak	40
53	white oak	35

(Tree data courtesy of VA Tech Department of Forest Resources and Environmental Conservation)

Tree Impact

Virginia Tech - Alternatvie Site

Proposed Construction Setback

Proposed Building Footprint

<24" DBH Trees to be Removed

>24" DBH Trees to be Removed

Projected CRZ Impact to Trees Outside Setback

Biohabitats
Incorporated

•Restoring the Earth and Inspiring Ecological Stewardship•