HABITAT MAPPING OF THE LAND AND VICINITY OF THE UNITED STATES DEPARTMENT OF ENERGY (DOE) PORTSMOUTH GASEOUS DIFFUSION PLANT (PORTS) PIKE COUNTY, OHIO

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Sponsored by Ohio University's PORTSfuture Project

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THE FACILITY AT PIKETON, OHIO

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1.0 Introduction

The Ohio University Voinovich School of Leadership and Public Affairs (GVS) was awarded a grant from the United States Department of Energy (DOE) Office of Environmental Management Portsmouth/Paducah Project Office (PPPO) to support the efficient and economical environmental restoration of the Portsmouth Gaseous Diffusion Plant (PORTS) Reservation. This document presents the findings of a specific task performed by GVS for DOE: a detailed, Geographic Information Systems (GIS)-based land cover classification of all surface natural and anthropogenic features of the PORTS reservation and those features of the adjacent private lands. The product provided is a database containing multi-layered information and analyses that can be used to address various questions pertaining to the natural character of the landscape and its biota for planning and management purposes. A broad range of informative queries and maps could be generated from this comprehensive dataset. The "top" informational layer represents the basic, observable features delineated from multiple remote sensing data sources, including Light Detection and Ranging system (LiDAR), secondary and tertiary products derived from LiDAR data using the Esri GIS platform, and several recent low-altitude aerial imagery sets. The mapping, provided in Esri geodatabase format, is linked to a separate database that includes the field sampling data, intensively collected from more than 150 primary sample locations, and a number of potentially useful analyses performed to yield both descriptive statistics for the habitats delineated and a set of relative valuations of the vegetated habitat in terms of inherent natural condition, composition, and diversity, among others.

The detailed site mapping encompasses the PORTS site; excluding the central industrial facilities contained within Perimeter Road but including the immediately adjacent private lands outside of the PORTS DOE land ownership within one mile of Perimeter Road (see Appendix A). The defined study area comprises approximately 5,235 acres. This document presents a summary of the data collected and analytical methods applied to characterize the existing habitats at and immediately adjacent to the DOE PORTS facility in Pike County, Ohio and to create a map of the existing habitats, as they existed during the 2010 to 2012 study period. The objectives of this mapping project include:

- Characterization of existing habitat in sufficient detail to allow assessment of its qualities and values for a variety of flora and fauna indigenous to southern Ohio
- Mapping of existing habitat in a GIS system that is spatially compatible with the PORTS GIS database
- Collect and catalogue qualitative and quantitative descriptive data that may be used and queried as needed to address a range of management questions
- To link other PORTS datasets with the new GIS product creating a multi-faceted, queryable database
- To demonstrate the function and usability of the created datasets to characterize and support management planning for wildlife habitat and other uses, including assessment of the potential future relinquishment of current federally-owned lands with the reservation
- To inform public stakeholders about the current habitat and land use on and around the PORTS reservation

Habitat characterization is commonly motivated by the need to manage land for some definable human purpose. Management purposes may range from active and continuous alteration of the conditions that are initially observed, to restoring perceived initial conditions that may have existed prior to an ongoing management state, to improving its productivity for newly targeted objectives or for favoring a particular species, or the preservation of habitat in a presumed natural state. A management plan requires information on habitat composition and quality to a detailed level that must be commensurate with the kind of management decisions needed within the time frame over which a desired outcome will be expected. The habitat characterization for this project includes field sampling to identify measure or count, when appropriate, the components of a habitat that may support a detailed level of site planning and management.

A summary of public involvement is presented in Appendix B.

This document presents the means, methods and findings for the mapping of habitats within the study area as identified during the study period beginning in March 2010 and ending in October 2012.

Report Format

This document is divided into four major sections and contains five appendices, designated as A through E. Section 1 provides information concerning the background and rationale for the study and mapping project, along with summaries of the past and present ecological conditions that contribute to the presently observable floristic and land usage configuration. Section 2 presents the mapping product, explains the land cover classifications identified, explains the mapping methodology, the field data collection process, data storage and some of the data analyses that can be used to describe and compare study area conditions. Section 3 presents an array of findings derived from analysis of the data and discusses the meanings of these findings. Section 4 presents an application of the mapping and land cover data to wildlife habitat assessment using the Habitat Evaluation Procedure (HEP) Habitat Suitability Index (HSI) models for several native wildlife species.

Systematic Mapping of the Study Area

The process for the division of the project area"s land surface (delineation) into separate irregular shapes (polygons) included concepts and approaches from both vegetation mapping and land use mapping. This landscape, as is true for the majority of the North American landscape south of the tundra, has been highly altered by more than 200 years of active use by modern society. Land use and land cover vegetation cannot be easily separated into groups or classes, particularly because present land cover represents a time-driven sequence of land use and abandonment changes. Discernible differences in land cover structure and composition display along a time gradient beginning most recently (within the last 100 years) with active agriculture clearing most of the land for pasture and cropland uses. "Natural" forested stands of vegetation today simply represent areas of the landscape that have not been actively used for longer periods of time, and for which the processes of natural succession and random chance have yielded the present condition, whereas roadway pavement represents areas that are being subjected to current, ongoing and intensive use. The many different uses and cover conditions that exist between those extremes reveals a pattern of use and abandonment of variable intensity since the time of last disturbance is expressed as a seral stage in the process of natural succession. All of these conditions can be definable as habitat. All of the various signature expressions are occupied and used at some time and for some duration in variable ways by both native fauna and humans. The term "habitat" is thus employed to recognize this essential characteristic of the delineated land use and vegetation polygons.

The non-vegetated portions of the study area include water bodies, occasional native rock outcrops and fabricated features. Fabricated features are named for their structure and function in common vernacular, such as roads, pavement, large buildings and earthen fills. Otherwise, vegetated areas can be classified into categories of natural (not recently or continually disturbed) and anthropogenic (maintained) vegetation. Maintained vegetation results from the frequent (more than once annually) disturbance such as mowing, cultivating, grazing and harvesting of vegetation. Although, maintained vegetation can also include forests planted and sustained for eventual wood crop harvest, represented by regularly planted pine stands. The majority of the study area is presently occupied by natural vegetation, in terms of the processes of sequential introduction of plant propagules and plant lifecycles generally entailed in the concept of natural succession of vegetation toward a climatic climax condition. Natural vegetation is assumed to have arrived at its present location and condition through means other than the focused intent and efforts of man.

There is a host of classification systems that have been used to map vegetation. They vary by scale and extent of the area involved as well as by the questions that a particular mapping effort was intended to address. This mapping effort and the products presented here do not precisely follow any named vegetation classification scheme. Approaches and procedures follow the basic principles of vegetation classification used by many of them.

Vegetation classification and mapping schemes may be based on either existing vegetation or on potential natural vegetation. Classification based strictly on existing vegetation can ignore the dynamism of plant growth and the sequential change in plant species composition toward a potential stable climax composition, if not disturbed by man, fire, disease infestation, or other perturberances. Alternatively, classification using potential natural vegetation is based on a belief that a final, stable vegetation composition will occur in time, and it will resemble the primeval condition based on current inferences for the existence of a predictable trajectory based in vegetation-site relationships. The Kuchler (1964, 1985) mapping of the potential natural vegetation of the United States for the National Atlas is one well-known example of that approach to vegetation classification. The classification used in this study is based on existing conditions but with recognition that natural succession is occurring and producing observable intermediate stages that appear to change directionally over time; annual herbs yield to perennial herbs, which yield to berry-bearing shrubs and small trees, which yield to nut-bearing saplings that finally grow into forests. Given the influence of infestation in our flora of non-native species, the continued influence of modern society, and the sway of climate change, the reoccurrence of a final, stable, and compositionally definable climatic climax vegetation is both unpredictable and may not exist in any previous primal form.

The two primary approaches to classification and mapping generally of either existing or potential natural vegetation include the physiognomic systems and the floristic systems. Physiognomic classification employs the form class of the vegetation (i.e.; tree, shrub, herb, etc.) using terms like forest, woodland, scrubland, grassland and aquatic plants. Different heights of the upper layer (canopy) vegetation and differing spacing of taller specimens are used as a basis for drawing lines of separation of form-based classification. Such an approach is most informing at a coarse mapping scale of 1:100,000 and greater relative fraction, and used when mapping a county, state or an entire country. While considering primarily physiognomy, vegetation form is often closely correlated with stand age and seral stage.

The second major systematic approach to vegetation mapping; the floristic method, uses the dominant composition of species of plants occupying a site. A floristic approach requires information only obtainable from on-the-ground observations designed to determine species composition and dominance. Such field sampling has been conducted as an important component of this project. The approach used for the PORTS landscape classification for identifying, delineating and naming vegetation areas combines physiognomic and floristic classification with modification to include structurally and compositionally definable intermediate stages in vegetation reoccupation of this relatively recently disturbed site.

Study Area Description and Location

The PORTS facility is located approximately 65 miles south of Columbus, Ohio (Figure 1.1) and is about 20 miles north of Portsmouth, Ohio. The reservation is located in the southeastern quarter of Pike County Ohio, approximately 8 miles south of the county seat, Waverly, and about 4 miles south of the village of Piketon (Figure 1.2). The DOE PORTS reservation, comprised of approximately 3,700 acres in Pike County, Ohio, is located at latitude 39º00‘30” north and longitude 83º00‘00” west measured at the center of the DOE reservation.

Figure 1.1 The location of PORTS in Ohio

Ecological Setting

"Habitat", like "environment" or "ecosystem", is a broadly encompassing concept that includes all of those things on or near the earth‟s surface that comprise, at least for a period, the living space for a population of organisms or a group of potentially interacting populations of organisms. The components of habitat include the soil, rock, surface form, water, fabricated objects, vegetation and fauna abiding at a definable location, subjected to a relatively narrow set of climatic variables and within a relatively brief period. All of these components vary dynamically and continuously across the surface of the globe due to influences of latitude, elevation above or below the surface mean, the size and distribution of land and sea masses, the details of geologic composition and of course the iterative effect all these have on climate. We thus can and do differentiate between habitats within a defined period and at a defined location on the earth‟s surface based on observable, measureable differences in some or all of the defining components as appropriate to the scale of management intended.

Habitat components thus include:

- Features fabricated and maintained by man
- Vascular plant species complement; a listing and a quantification or estimation of relative importance
- Site occupation by live plants; various density metrics; ground cover, basal area, stems per unit area

- Non-living components of habitat; presence surface water; openings in rock faces, trees, stumps and the soil that may serve as habitat
- Topographic, geometric, edaphic and hydrologic factors that affect plant and animal distribution such as slope, aspect, drainage and shallow soil profile
- Incident and recurrent conditions, such as weather, drought, flooding that influence biotic composition and structure

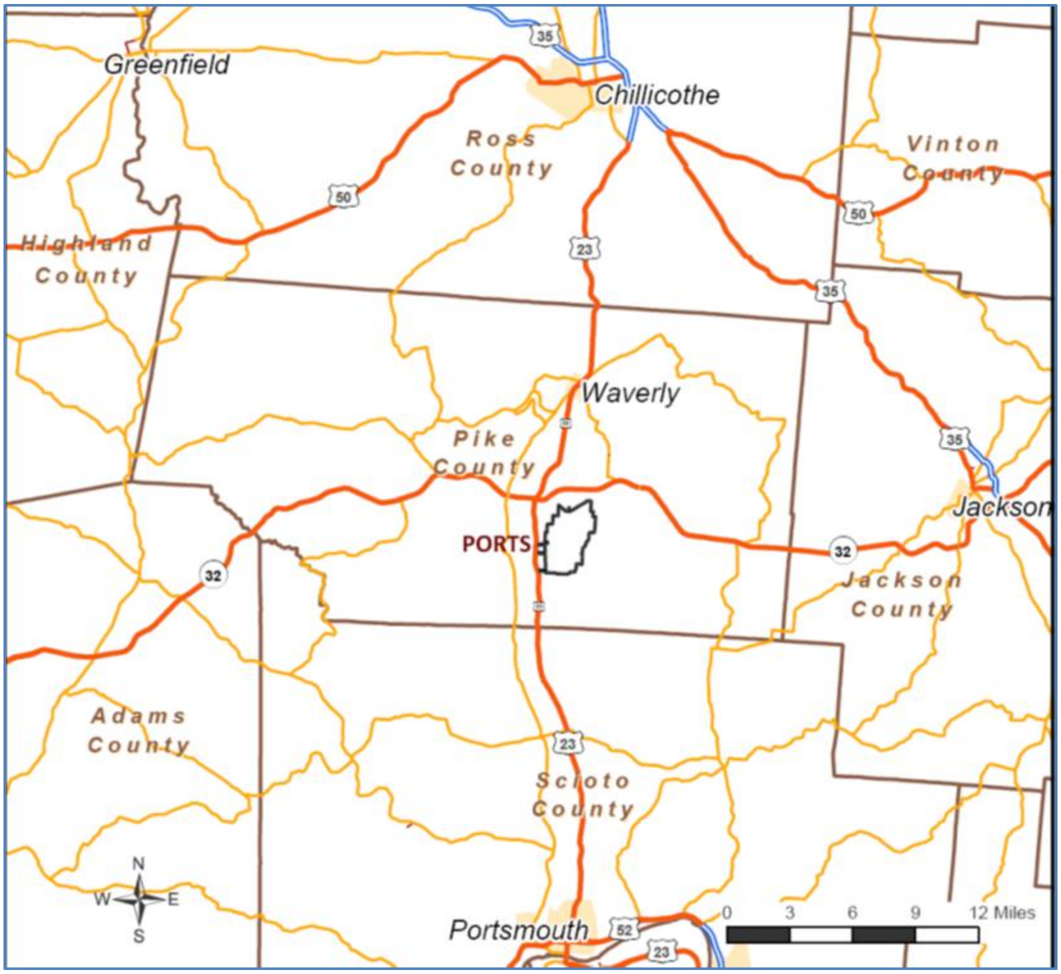

Figure 1.2 The location of PORTS in south central Ohio / Pike County

The time-frame for this habitat characterization includes 2010 through 2012 (the period of direct assessment) and the period of the recent past and the near future for which we may intuit conditions from an understanding of the present conditions through the lens of historical, geological and biological knowledge of ecologic pattern and process in this ecological region or biome. The study site is located along the left descending bank of the Scioto River Valley within the Silurian, Devonian and Mississippian-age shale and sandstone bedrock of the southwestern portion of the unglaciated Allegheny Plateau. Because the site has not been subject to glacial coverage, it has been deeply dissected by erosion, creating a highly variable surface topography that offers a variety of habitats for plants and animals.

The composition of organisms present, particularly vascular macrophytes (large plants), has been historically employed to differentiate and classify habitats. Large plants, substrate and water are the identifiable, measureable components of habitat within which fauna live. The physical influences of climate, substrate (rocks and soil) and surface shape (topography) cause plant species to recur in repetitive groups, or communities. The presence of definable plant communities predicts the likelihood of inhabitation by communities and populations of animal species and may, with sufficient detail on the composition, be used to model population levels, as addressed in Section 4.0 of this document.

Habitat may be characterized as it presently exists or as it may have existed prior to significant human influences. The influence of time as a consideration for characterization of past ecosystem structure may be intuited or inferred from geology, geomorphology, fossil pollen studies, tree-rings and most recently; early European settlement surveys. For example, the sedimentary structure and carboniferous content of the local bedrock demonstrates that the site would have been dominated by tropical fern-cycad-lycopod swamps and then temperate shallow estuarine environments in the last 350 to 70 million years before the present era (BPE). Extensive evidence of glaciation just north of the site provides a very strong argument that the site ecosystem has ranged from an arctic barren, to tundra, taiga, to boreal coniferous forest and most recently, deciduous forest within the last 18,000 to 8,000 years BPE.

Slow to rapid changes in physical influences causes habitats to undergo constant change. Climate generally changes slowly but its effects are expressed year-by-year and century-by-century as changes in habitat structure and composition. Factors such as disease may rapidly alter habitats. Sears (1926) for example mapped the virgin forest of the area (circa 1798 to 1820) as mixed Chestnut-Southeastern Complex Forest. Braun (1950) characterizes the site as occurring within the Mixed Mesophytic Forest Region of the Eastern Deciduous forest of northeastern North America; most of the chestnut had been lost to blight, while some of the diversity had succumbed to agricultural development. The level III Ecoregion classification (Commission of Environmental Cooperation 2006) identifies the including biome as the Western Allegheny Plateau component of the Eastern Temperate Appalachian Forest. This classification considers the present and probable recent past potential natural vegetation within a climatic zone and a geologic setting. It does not consider one important factor, time since last significant disturbance, which participates importantly in the present habitat-mapping project.

1.4.1 Climate

Located in South-Central Ohio, in the western foothills of the Appalachian Mountains, the region around the site experiences a relatively continental climate, characterized by moderate temperature and precipitation extremes. Using meteorological data collected in Waverly, Ohio (Station GHCND: USC00338830) at 39.1114°N, -82.9797°W and at an elevation of 560 feet above sea level. The site, located approximately 7.5 miles NNE of PORTS, has been in operation since 1948 and is still operational to date (NOAA 2012).

The average yearly temperature is 53.3°F with an average annual maximum of 64.9°F and an average annual minimum of 41.6°F. July is typically the warmest month with an average monthly temperature of 75°F with an average diurnal fluctuation of 22.7°F. January is typically the coldest month of the year with an average temperature of 29.9°F and an average diurnal fluctuation of 19°F. However, the months of April and October have the largest diurnal temperature range of 26.5°F and 26.8°F, respectively (NOAA 2010).

The average annual precipitation at Waverly, Ohio, for the period from 1981 to 2010 was 40.56 inches, while the average annual snowfall for the area is only about 9.5in. Heavy amounts of rain associated with thunderstorms or low-pressure systems will fall in a short period. The greatest daily rainfall during this period was 4.9 in., occurring on March 2, 1997 (NOAA 2010), while some surrounding areas received much more.

According to USEC (2004) the average wind direction at PORTS was from the South West and the winds were most frequent from the South. Also, the average wind speed recorded at the standard 10 m was 4.0 mph.

1.4.2 Air Quality

As directed by the Clean Air Act (CAA) of 1970 (42 U.S.C. §7401), the EPA has set the NAAQS for several criteria pollutants to protect human health and welfare (40 CFR Part 50). These pollutants include particulate matter less than 10 microns (PM10), particulate matter less than 2.5 microns (PM2.5), sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO2), lead (Pb), and ozone (O_3). According to previous DOE reports, the Piketon region is classified as an attainment area for the pollutants listed in the NAAQS and the existing air quality on the site is in attainment with NAAQS for the criteria pollutants. Also, that OEPA issued a Title V permit with an effective date of August 21, 2003. Under the Title V regulations, the United States Enrichment Corporation has 66 non-insignificant sources and 151 insignificant sources (USEC 2004).

While the NAAQS standards in the region are within attainment limits, the Ohio River Valley is prone to frequent pollution episodes (Yatavelli *et al.* 2006). Local and regional sources can combine with long-range transported pollutants to create or amplify these episodes. These events are often associated with frontal systems that move through the area, trapping and accumulating pollutants ahead of the system. Subsequent rainfall washes pollutants from the air column and wet-deposit across the landscape. Dry deposition of pollutants from the atmosphere prevails otherwise. These pollutants not only include EPA criteria pollutants regulated by NAAQS, but many others including heavy metals and acid rain products.

The deposition of acidified rain, snow, sleet, hail, acidifying acids and particles, as well as acidified fog and cloud water is commonly referred to as acid rain. Acid rain can acidify surface waters, damage terrestrial and aquatic ecosystems, and degrade soil quality (Likens 2010). Acid rain measurements collected in Ohio by the National Atmospheric Deposition Network"s (NADP) and the National Trends Network (NTN) since 1978 have consistently showed that southeast Ohio (OH49) receives acidity precipitation higher than any other location in the continental US. Other NTN sites in Ohio show marginally lower concentrations (NADP 2012). The National Trends Network measurements have demonstrated a clear trend of improvement over the past 30 years partially as a result of the Clean Air Act Amendments of 1990. In 1980, the annual average pH of precipitation at OH49 was 4.07 in 1980 and was 4.61 in 2010, where a pH of 7 is neutral and values lower than 7 are acidic. The deposition of nitrate and sulfate ions has also improved. Nitrate and sulfate ion deposition was 20.09 and 41.39 kg/ha in 1980 and 7.43 and 12.61 kg/ha in 2010, respectively.

The effect of air pollution deposited into ecosystems is not well understood, however much work is being conducted to determine what critical loads are required before effects are observed. Critical loads are defined as "the quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment are not expected to occur according to present knowledge" (NADP 2009). While the ecosystem observed during this study has likely suffered from the effects of pollution deposition, at this point the critical loads are undetermined.

1.4.3 Geology

The Reservation is located entirely within the Knobs-Lower Scioto Dissected Plateau portion of the Western Allegheny Plateau Physiographic Ecoregion (Figure 1.3). The region is characterized by the rugged, dissected, steep slopes and ridges standing in high relief over low gradient, broad valleys, as represented by a digital elevation model (DEM) in Figure 1.4 (USEPA 2011). The slopes and ridges of the region remain mostly forested with a combination of mixed oak and mixed mesophytic forests, which are typically underlain by Mississippian-age shale and sandstone formations.

The bedrock geology units that outcrop in this region were deposited between the late Devonian through the late Mississippian Periods (Figure 1.5). The subsequent uplift of the region gently folded the strata to form a shallow basin that trends parallel to the Appalachian Mountains. Subsequent erosion of the uplifted sediments produced the deeply dissected, knobby terrain that characterizes the region today. The geologic structure of the area is simple and dominated by relatively flat-lying Paleozoic shale and sandstones that are overlain by Pleistocene fluvial and lacustrine deposits (Slucher 2006). The near-surface geologic materials that influence the hydrologic system of the site consist of several bedrock formations and unconsolidated deposits (USEC 2004).

Bedrock consisting of clastic sedimentary rocks underlies the unconsolidated sediments beneath the site. The geologic structure of the area is simple, with the strata dipping gently to the east-southeast. No known geologic faults are located in the area; however, joints and fractures are present in the bedrock formations. The Ohio Shale, the oldest stratigraphic unit potentially exposed at PORTS, is composed primarily of dark brown carbonaceous silty shale with minor beds of blue-gray mudstone. The Bedford Shale and Berea Sandstone overly the Ohio Shale and are the oldest strata known to outcrop at PORTS. These outcrops are present within the deeply incised streams and valleys throughout the reservation (USEC, 2004).

The Mississippian-aged Sunbury Shale and Cuyahoga Shale overlay the Devonian-aged Bedford and Berea formations. The Sunbury Shale apparently thins westward as a result of erosion by the ancient Portsmouth River, and is absent on the western half of the site (USACE 1993). The Sunbury Shale also is absent in the drainage of Little Beaver Creek downstream of the Lime Sludge Lagoons and the southern portion of Big Run Creek, where it has been removed by erosion. The Cuyahoga Shale, the youngest and uppermost bedrock unit at PORTS, forms the hills surrounding the site, particularly to the east. It has been eroded from other portions of the site, however regionally it can reach thicknesses of 160ft (USEC 2004).

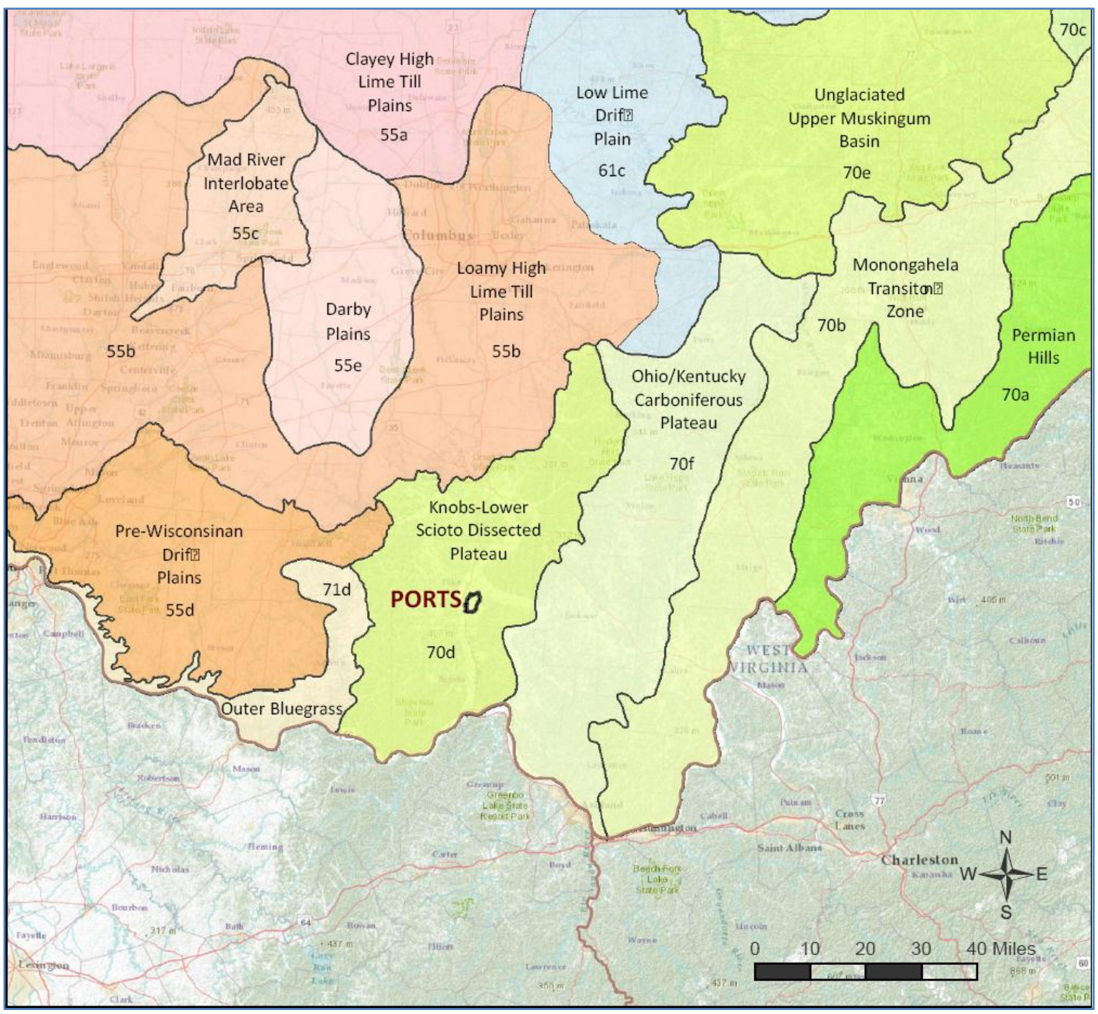

Figure 1.3 The physiographic ecoregions of southern Ohio

The floodplains and valleys that were largely unaffected by the recent Quaternary glaciations are typically narrow and commonly occupied by small farms. However, remnants of ancient waterways that existed in the region around PORTS are evident across the landscape. Prior to the Pleistocene glaciation, the Teays River and its tributaries were the dominant drainage system throughout Ohio (Tight 1903).

The ancient Teays River carved a massive valley through part of southern Ohio. The ancient valley is quite prominent in areas north and northeast of PORTS. The Teays River was dammed by the initial glaciation of the current ice age beginning around 2.58 million years ago. The valleys south of the glacial maximum filled with floodwaters forming Lake Tight. Lake sediments, supplied by the seasonal melt waters of the enormous ice sheets, filled the valleys with as much as 720 feet of glacial drift (Figure 1.6). These deposits, specifically the Minford Clay, were deposited between 2 million and 690k years ago as evidenced by the reversed magnetic polarity of the clay, linking it to the period when the Earth‟s magnetic polarity was reversed during the Matuyama Reversed Polarity Epoch (ODNR 1987). The broad valley now provides a miles-wide swath of arable farmland for residents of Pike County.

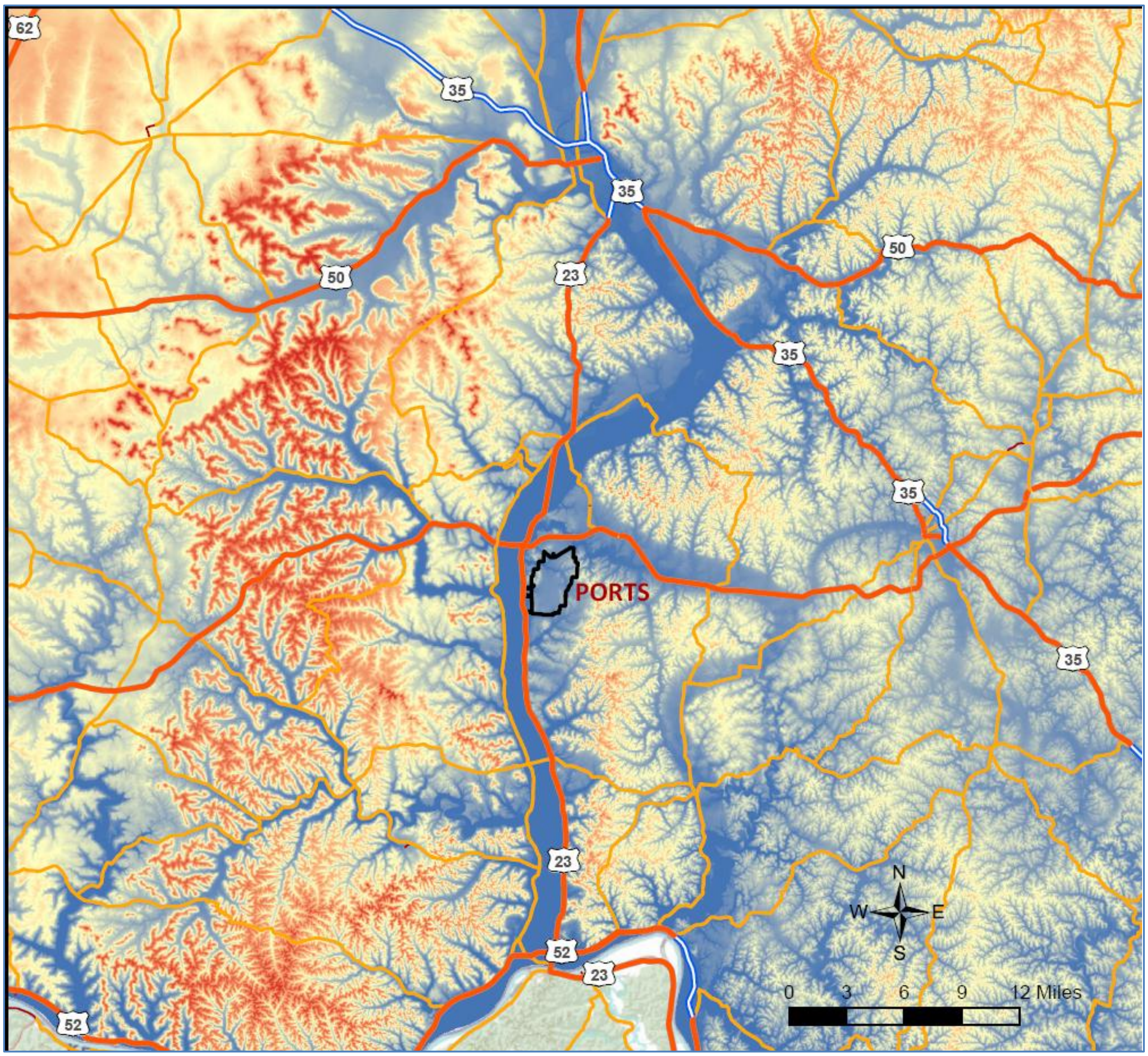

Figure 1.4 Digital elevation model (DEM) of the vicinity of PORTS

The ancient Portsmouth River, a tributary to the Teays River that existed at the same time, was ultimately modified by the ice age by eliminating its outfall point into the Teays system. A large meander of that tributary flowed through the PORTS site, cutting down through the Cuyahoga Shale and into the Sunbury Shale and Berea Sandstone (USACE 1993). It deposited the fluvial silt, sand, and gravel of the Gallia member of the Teays Formation that underlies most of the PORTS industrial complex within Perimeter Road and areas south and southeast of the reservation.

Apart from those upland areas mostly unchanged by events that occurred during the Pleistocene, the landscape is dominated by glacial morphology, comprised mostly of perched outwash terraces and lake deposits (Figure 1.7). The initial damming of the Teays River, formation of Lake Tight, and retreat of the Pre-Illinoian ice resulted in a highly modified drainage pattern throughout Ohio known as the Deep Stage. During this interglacial period, regional uplift emphasized the erosional processes of the Deep Stage river systems (Stout and Lamb, 1938). The Newark River, which mostly occupied the present day Scioto River valley in Pike County, flowed in the opposite direction as the Portsmouth River and flowed into the Cincinnati River near Portsmouth, Ohio.

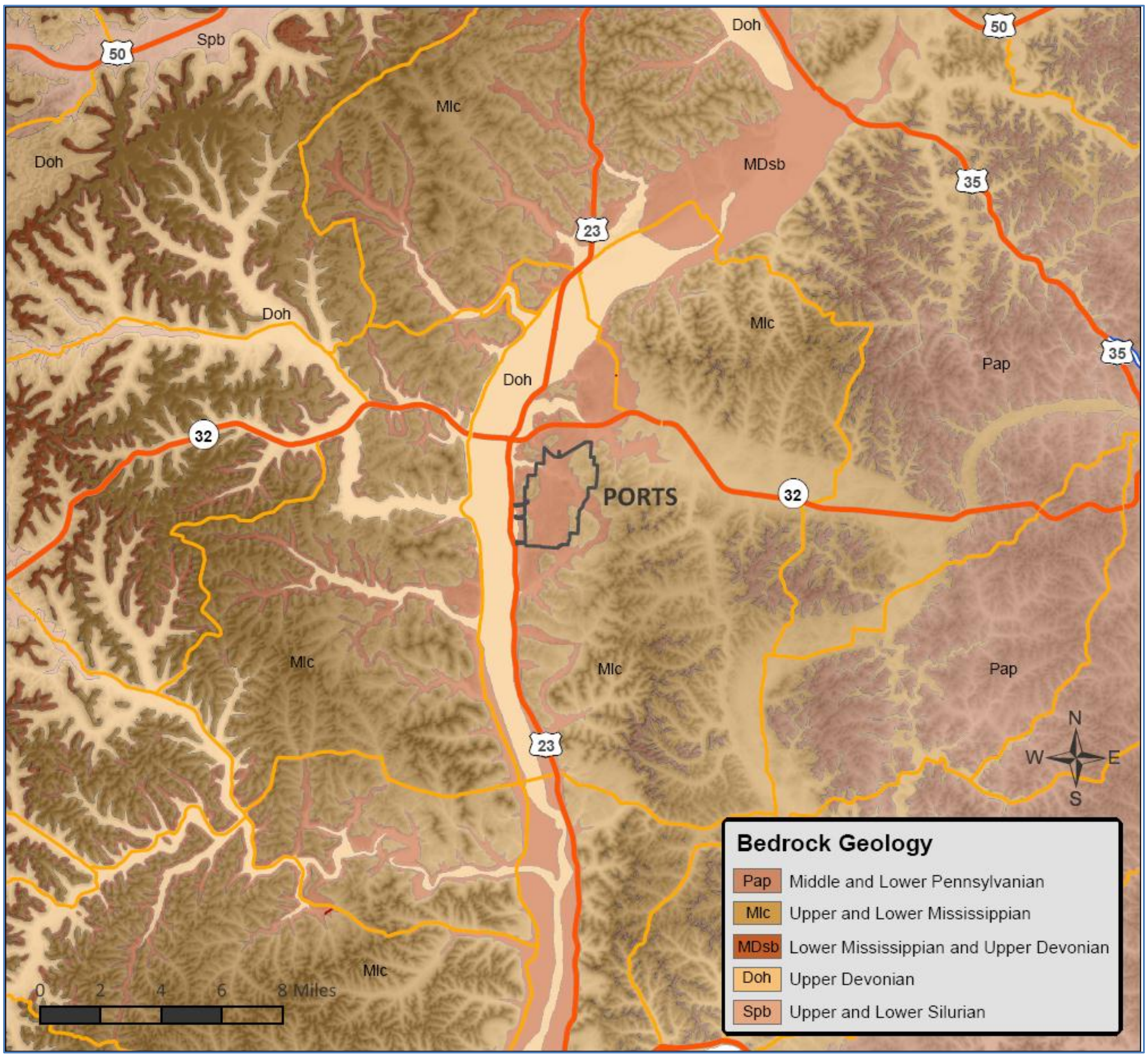

Figure 1.5 The bedrock geology of the PORTS region (Slucher, 2006)

The Newark River and other Deep Stage systems remained relatively undisturbed until they were buried under a thick mantel of drift and outwash by the melting Illinoian glacier some 200,000 years ago (Stout and Lamb, 1938). Evidence of that mantel can be observed in the NW portion of the PORTS reservation in the lower reaches of the Little Beaver Creek. The eroded terraces lie north and south of the Little Beaver Creek channel rising as much as 150ft above the Scioto River. Agricultural fields on the Van Meter and Montgomery properties adjacent to PORTS clearly outline the erosional edge of the Illinoian terraces.

After the retreat of the Illinoian ice sheet, the modified Deep Stage drainage system south of the glacial maximum began to resemble the present system. The lower reaches of the Scioto River had found a course along the old Newark River channel through Pike County (Stout, 1953). The subsequent Wisconsin glaciation beginning some 100,000 years ago and reaching its maximum about 21,000 years ago contributed to the glacial morphology apparent within the modern Scioto valley. Most notably, the intermediate-level outwash terraces formed from 15,000 – 18,000 years ago are present along much of the western boundary of the PORTS reservation.

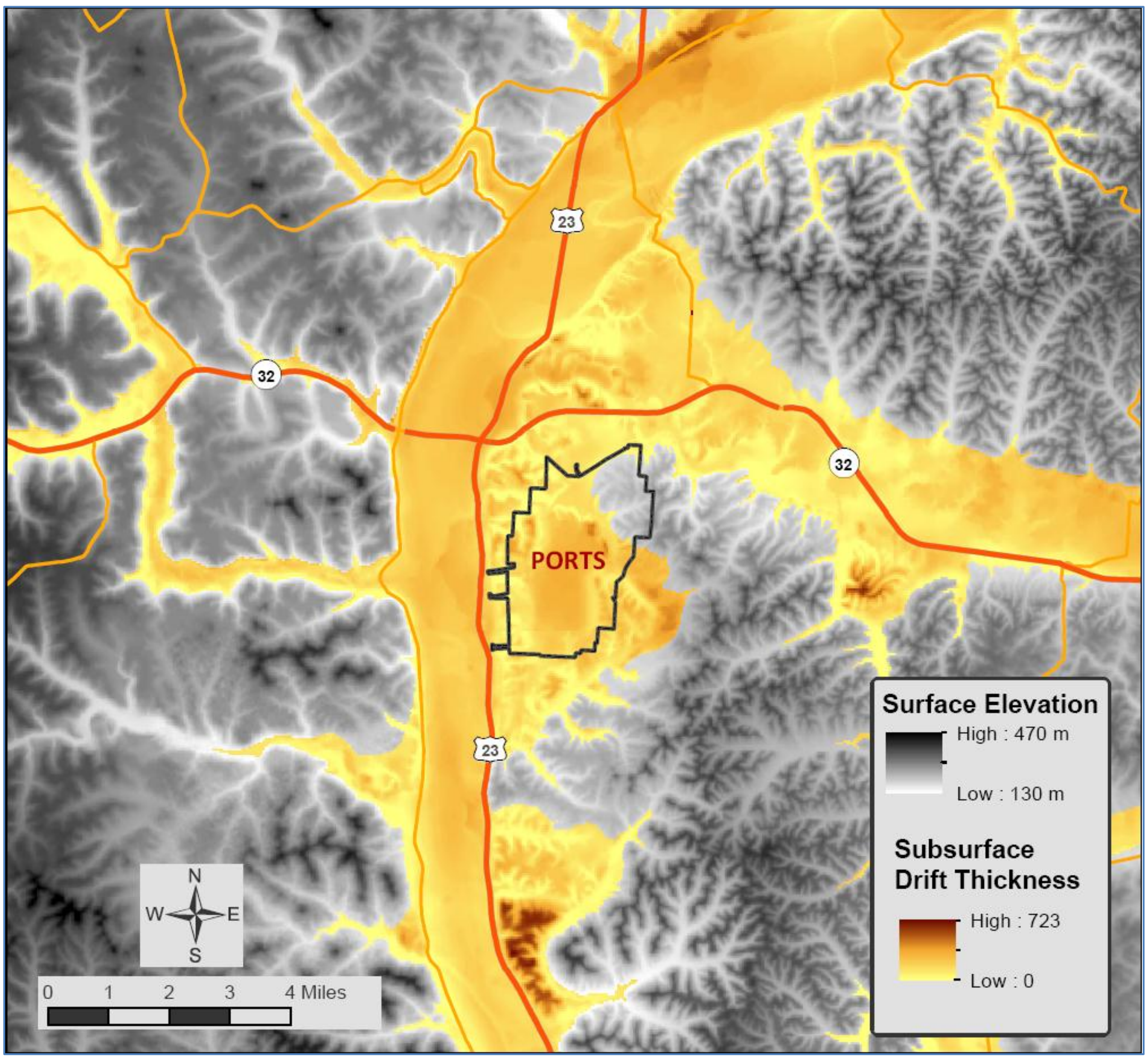

Figure 1.6 The drift thickness of glacial sediments from the surface in the PORTS region (Powers, 2004)

Sitting about 100 feet above the current Scioto River, this erodible terrace is comprised of coarse sands and gravel. These terraces provide unconfined groundwater movement through the permeable sediments to support fen wetland habitats. Several fens that were identified during this study occurred on the eroding slopes or at the base of these terraces. Several characteristic fens were discovered on the Sea property near the southwest corner of the PORTS reservation. The fens were limited in diversity due to grazing, but other fens are likely to occur along other portions of the terrace slopes.

1.4.4 Soils

The soil is the unconsolidated geologic layer within which most plants are sustained. Soil is the result of the geologic parent material modified by chemical, physical and biological processes (including the activities of man) that proceed over various time gradients since the last major disturbance. Soil is the matrix that provides plants with water and nutrients and thus has a very powerful effect on the local dominance of species and of the habitats into which they are sorted. Soil controls the movement and distribution of water and the ability of plant roots to extract water from it. Soil provides the habitat for the host bacteria, fungi, invertebrates and vertebrates that continually modify and generally improve the soil for plant growth between disturbance events.

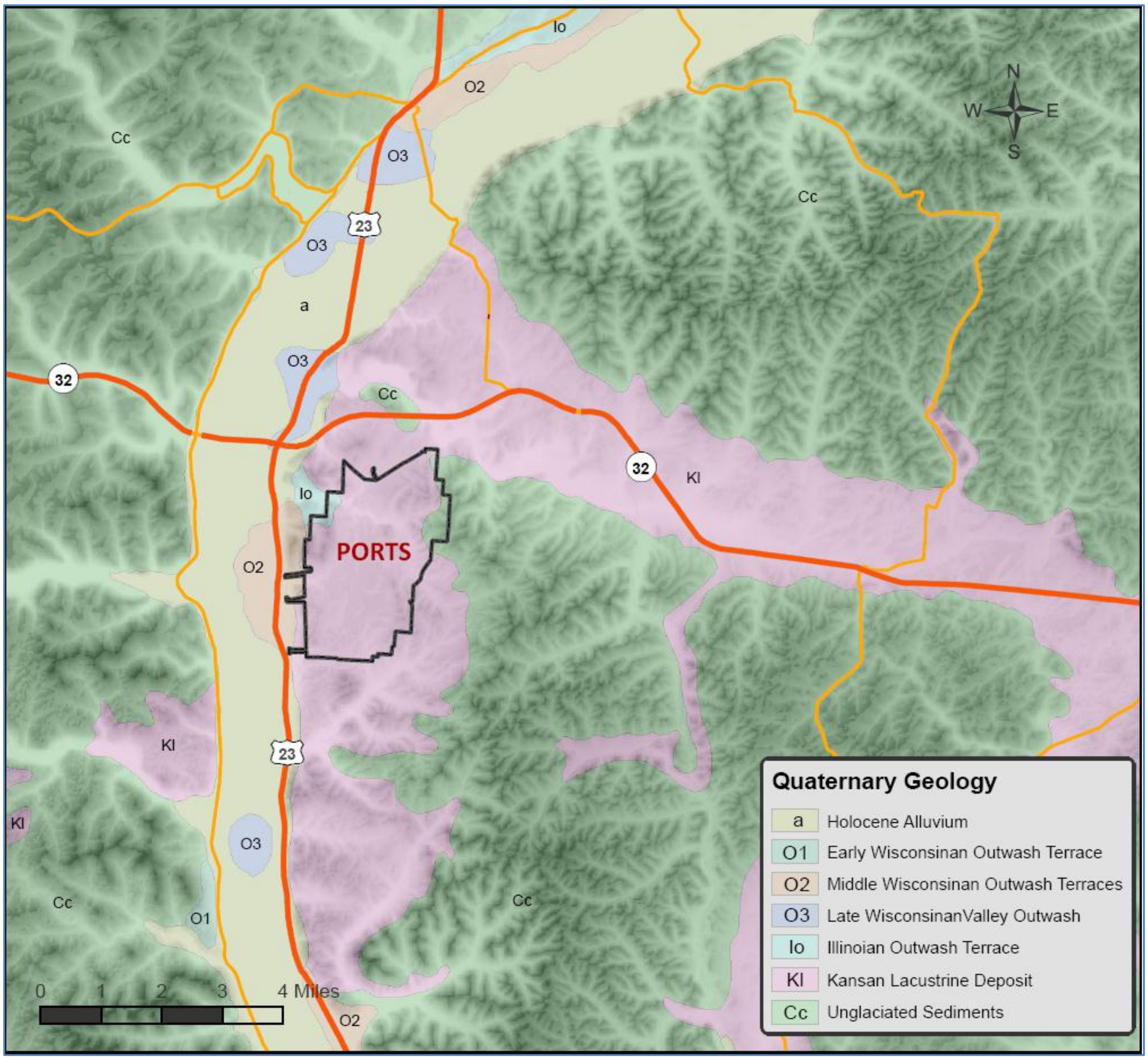

Figure 1.7 The classification of quaternary geology in the PORTS region (Pavey, 1999)

The 1990 Soil Survey of Pike County Ohio (ODNR, USDA) General Soil Map identifies three soil families within the study area; the Omulga, the Shelocata-Latham (SL) and the Genesee-Huntington-Fox (GHF). The Omulga family of soils is formed in parent material composed of wind-blown fine sand and silt deposited on flats and lowlands during the late Pleistocene and early Holocene. The Shelocta-Latham soils are formed in residual and colluvial material from Devonian to Mississippian age siltstone, sandstone and shales on ridge tops and slopes in the dendritically eroded uplands. The Genesee-Huntington-Fox soils form in the Scioto river alluvium and the glacial outwash materials along upper flood plain terraces on the southwestern side of the project area. There are 31 different mapped soil series within the study area. Many of the variants are based on primarily slope differences. The majority of different series occurs with low frequency and account for only approximately 10% of the study area. The remaining 90% of the site is composed of ten different series, approximately equally divided into the three soil families.

The majority of the study area is mapped as the Omulga Silt Loam. Omulga soils are generally formed in windblown silts and fine sands (loess) deposited on southwest facing slopes, terraces and lowlands during glacial retreat. Shallow soil sampling during field data collection revealed that most surfaces were capped with 4-inches to greater than 12 inches of loess material. The typical Omulga soil forms in loess deposited on water surfaces and wetlands, which accounts for it characteristic fragipan formed of organic and iron crusts. The Omulga soils occupy all of the central industrial portion of the PORTS reservation and many of the more level upper valley terraces of all the drainage channels, which may have been inundated before erosional breakout of the ancient lake waters. Omulga soil is somewhat poorly drained due to both the fine particle size and the common fragipan. This soil compacts easily and may support a wetland plant community following heavy use. Alternatively, it is very susceptible to erosion when exposed to direct rainfall due to the relatively low clay content. Much of the Omulga within the study area has been disturbed by industrial or agricultural activities due to its occurrence on relatively level areas. If undisturbed for long periods it will likely support Mixed Mesic and Oak-Hickory forest.

Soil series in the SL family of soils include five defined loams, silty clay loams and clay loams formed on residual siltstone the colluvial materials from them within the eroded hill country in the north and east sides of the study area. These tend toward acidity due to carbonate depletion and vary in depth to bedrock. The most common are the Rarden Silt Loam and the Coolville Silt Loam. Most of these types appear to have been cleared early during settlement and overly used as pasture. Erosion has removed much of the organic topsoil and nutrients. Particularly eroded areas support stands of native pine. Slightly better quality soils, particularly on south-facing slopes, support Oak-Hickory Forest.

Soil series in the GHF family include four series that form in recent alluvial materials, mostly within the Scioto River floodplain and adjacent terraces. The dominant series mapped within the project area is the Princeton Fine Sandy Loam, which forms in Wisconsin-age sandy to gravelly outwash materials on the highest Scioto floodplain terraces. The Fox Loam forms in the newer sediments in the lower river terraces and tends to favor Bottomland Hardwood Forest (BLHF) but in lowest positions may support palustrine forested wetlands. The Huntington Silt Loam displays a mollic horizon, suggesting formation during xeric glacial periods on glacial water outwash terraces. These tend to be excessively well drained and low in nutrient availability. The Clifty Silt Loam forms on colluvial and alluvial materials in narrow valleys carved into the project area by the two perennial streams and their major tributaries and supports both BLHF and Mixed Mesic Forest (ODNR, USDA 1990).

1.4.5 Topography and Hydrography

Topography, the shape of the land surface resulting from large scale and long-term geologic events continually modified by erosion and deposition, strongly influences the character and distribution of vegetation habitats. Topography, particularly the dendritically eroded land surface found within the PORTS study area offers a highly varied surface with a variety of microclimatic and micro-edaphic conditions expressed as slope, solar aspect, drainage and water retention.

1 INTRODUCTION

Temperature and moisture retention are key environmental factors controlling species composition and plant community structure. Receiving less direct solar exposure, north-facing slopes tend to be cooler and tend to lose less moisture than excessively well-drained ridge tops and south-facing slopes. The steepness of slopes strongly affects water retention and the local ability for precipitation to infiltrate to roots. Water percolation and transport through shallow soils from uplands to lowlands often results in toe of slope springs and seeps, which often creates unique assemblages of plants into fen-like communities. The direction of prevailing winds and the shape of the land surface define depositional areas for organic materials (leaves), which, in turn, facilitate water retention and infiltration while slowing runoff and preventing erosion.

The topographic land surface of PORTS study area resembles a bowl with a raised bottom and a somewhat irregular rim composed of deeply eroded hills. The PORTS industrial center occupies the bottom of the bowl which is a former glacial lake bottom. The ancient lake breached the rim at low points, eroding valleys to the north, south and west. Elevations range from approximately 670 above mean sea level in the bowl bottom to lows in erosion valley bottoms of 50 to 130 feet lower. The surrounding hills range from heights above the industrial bowl bottom of 80 to 220 feet, with the highest elevation at approximately 890 feet along McCorkle Road on the northeast fringe of the study area. The overall study area relief is approximately 350 feet, with the low at approximately 540 feet elevation near the southwest corner of the study area in an upper terrace of the Scioto River flood plain.

Overall drainage direction is toward the west to the Scioto River valley. The northern one-third of the study area is drained through multiple unnamed tributaries to Little Beaver Creek, which joins the Scioto River tributary Beaver Creek approximately 900 feet west of the northwest study area boundary. The southeastern one-quarter of the study area drains to the named Scioto River tributary Big Run, which joins the main stem approximately 4000 feet southwest of the study area boundary. The remaining portion of the study area drains directly to the Scioto floodplain by way of a series of ten parallel, westward-flowing unnamed rills.

2.0 Habitat Mapping

Existing vegetation includes all of the prevailing plants visible to the naked eye. The types of vegetation present are strongly affected by the surficial geology (including soils), recent prevailing climatic factors; temperature and moisture regimes, prevailing winds, latitude and magnitude of solar insulation, the competition between species of vegetation and by faunal influences (particularly pollinators and seed transporters). These factors appear to result in the accumulation of species into limited groups that may be considered at a regional scale as temporally significant, "climatic climax" vegetation and at a local scale as a plant community (Clements 1916).

There are no primeval landscapes in this region of North America. The entire landscape within the area of the PORTS site has been frequently disturbed over the last 200 years by colonizing Europeans and over the previous 15,000 or so years by expanding populations of "native" human populations. Fire, climate change, glaciation and overall landscape surface erosion have also played important roles in the continuing process of disturbance and reestablishment of vegetation. With an average annual local delivered precipitation rate of greater than 40 inches well distributed throughout the year, it may be assumed that the recurrent and abiding condition of the landscape in this region is vegetation-covered (Prism 2011). The process of vegetation reestablishment, summarized by the term "natural succession" includes the series of apparently inevitable events that begin immediately after perturbation and proceed until the climatic climax vegetation is again established.

The natural successional process begins with the introduction of viable propagules (seed, roots, corms, tubers and stems) through the pathways of wind, water, gravity and faunal introduction vectors. Successional processes include growth of propagules, the effects of life cycle (biennial, annual, perennial), species competition, foraging effects and pollinator effectiveness. An initial group of species is replaced over time by another group, which may yield to another group until a relatively stable, mature state is attained in vegetation composition and density. The steps through which vegetation reoccupation proceed (seral or successional stages) generally include initial colonization by annual, often weedy, species of herbs and grasses, perennial herbs and grasses, mixed shrubs and herbs, mixed saplings of forest trees and shrubs, forest canopy saplings and finally a canopy dominated by mature forest trees (Curtis-McIntosh 1951). This process plays out over periods of scores to hundreds of years.

The stable condition for this region, at least for periods relevant to a human lifetime, is a group of trees that make up the Temperate Deciduous Forest Biome (Braun 1950). This biome, which includes much of the area between the Mississippi River to the Atlantic Coast, and southern Ontario to the south Appalachian Mountains, is characterized by variable precipitation that ranges from 28 inches per year in the northwestern section of the biome to more than 60 inches in the southeastern mountains, with precipitation distributed evenly throughout the year. Frost occurs throughout the biome and summer and winter are distinct seasons. The dominant canopy plant species of the biome are broad-leaved deciduous trees although native pine stands occasionally prevail. There are eight recognized forest complexes throughout this biome; four of which converge and intergrade in the locale of the study area (Braun 1950). None are either fully represented by the possible array of potentially occurring species, nor are they widely distributed, varying in response to local variability in growing conditions.

Generally, the older forests develop greater complexity of structure and a corresponding increase in diversity of habitats therein contained. The organic content of soils is increased with passage of time since disturbance. The range of stem sizes increases as shade-tolerant, berry-producing understories become established. Older trees incrementally perish, leaving cavities used for denning. Limbs and logs cover the forest floor, again providing increased habitat and forage opportunities for a widening number and kind of species as fungi colonize the woody remains. The time-driven increase in habitat diversity and structural complexity increases the value of the mature forest to the native fauna and to the human conservationist intending to preserve these values.

2 HABITAT MAPPING

The habitats and land use classification methods used for this project is a combined physiognomic and floristic method based on use of both remote sensing data and field sampling. Since the map produced is a discrete, non-overlapping tiling of the study area, all non-vegetated features and land uses are also mapped. Mapping features, including both vegetation association and land use classifications, are grouped into upper level cover categories for listing and discussion. Cover categories allow for a higher level of planning and management for the consideration of features with general similarity, but differ in detail. Appendix A, printed separately, is the map of the habitats and land uses observed in the study area. Tables 2.1 and 2.2 present the areal statistics for cover categories and habitat/land use classifications for the total study area and separately for the PORTS lands only.

Table 2.1 Summary of Habitat/ Land Use Classification within the Study Area

Habitat/Land Use Classification	Acres	% Study Area	Polygon Count	Acres by Category	% by Category
Category 1: Surficial Geologic Features					
Natural Streams	24.25	0.46%	36		
Rock Outcropping/Shelf	0.79	0.02%	9	25.04	0.48%
Category 2: Mature Upland Native Forest					
Oak-Hickory Forest	687.48	13.13%	138		
Mixed Mesic Forest	850.29	16.24%	182		
Bottomland Hardwood Forest	228.32	4.36%	137		
Native Pine Forest	135.85	2.59%	143	1901.94	36.33%
Category 3: Wetlands					
Palustrine Forested Wetland	25.89	0.49%	33		
Palustrine Shrub-Scrub Wetland	16.42	0.31%	37		
Palustrine Emergent Wetland	22.62	0.43%	90	64.93	1.24%
Category 4: Successional Uplands					
Successional Forest	288.77	5.52%	103		
Successional Scrub	217.28	4.15%	166		
Oldfield - Successional	594.17	11.35%	144		
Ruderal Shrub-Sapling	59.24	1.13%	65		
Ruderal-Scrub	117.45	2.24%	112		
Ruderal Successional	125.41	2.40%	52	1402.32	26.78%
Category 5: Agricultural Uses					
Planted Pine Stand	98.20	1.88%	66		
Hay/Pasture	627.90	11.99%	68		
Row Crops	137.43	2.62%	15	863.53	16.49%
Category 6: Maintained Vegetation					
Mowed Grass/Lawn	288.31	5.51%	147		
Planted Restoration Site	66.86	1.28%	17		
Cemetery	10.02	0.19%	10		
Powerline Corridors	200.79	3.84%	58		
Domestic Lawn and Appurtenances	203.64	3.89%	68	769.62	14.70%
Category 7: Transportation Features					
Primary Roads: Pavement Asphaltic	48.46	0.93%	27		
Secondary Roads: Pavement Gravel or Earthen	34.75	0.66%	47		
Railroad Structures	10.18	0.19%	7		
Bridges/Abutments/Culverts	0.65	0.01%	37	94.04	1.80%
Category 8: Anthropogenic Uses					
Buildings/Facility	34.00	0.65%	36		
Paved Areas/Outdoor Storage	18.81	0.36%	16		
Fill/Excavations/Sludge	22.04	0.42%	15		
Ponds and Wastewater Impoundment	32.31	0.62%	62		
Water Conveyance/Control	6.94	0.13%	42	114.10	2.18%
Grand Totals	**5235.52**		**2185**		

Table 2.2 Summary of Habitat/ Land Use Classification within PORTS Lands Only

Habitat/Land Use Classification	Acres	% Study Area	Polygon Count	Acres by Category	% by Category
Category 1: Surficial Geologic Features					
Natural Streams	10.29	0.42%	14		
Rock Outcropping/Shelf	0.79	0.03%	9	11.08	0.45%
Category 2: Mature Upland Native Forest					
Oak-Hickory Forest	403.43	16.36%	92		
Mixed Mesic Forest	481.29	19.52%	129		
Bottomland Hardwood Forest	137.49	5.58%	78		
Native Pine Forest	110.97	4.50%	121	1133.18	45.95%
Category 3: Wetlands					
Palustrine Forested Wetland	19.91	0.81%	17		
Palustrine Shrub-Scrub Wetland	8.20	0.33%	16		
Palustrine Emergent Wetland	10.05	0.41%	46	38.16	1.55%
Category 4: Successional Uplands					
Successional Forest	136.25	5.52%	53		
Successional Scrub	105.43	4.28%	77		
Oldfield - Successional	133.91	5.43%	78		
Ruderal Shrub-Sapling	53.12	2.15%	50		
Ruderal-Scrub	56.36	2.29%	74		
Ruderal Successional	74.32	3.01%	45	559.39	22.68%
Category 5: Agricultural Uses					
Planted Pine Stand	38.58	1.56%	32		
Hay/Pasture	1.29	0.05%	2		
Row Crops	0.09	0.00%	1	39.96	1.62%
Category 6: Maintained Vegetation					
Mowed Grass/Lawn	275.04	11.15%	127		
Planted Restoration Site	62.83	2.55%	17		
Cemetery	3.73	0.15%	5		
Powerline Corridors	182.73	7.41%	50		
Domestic Lawn and Appurtenances	2.61	0.11%	9	526.94	21.37%
Category 7: Transportation Features					
Primary Roads: Pavement Asphaltic	21.50	0.87%	14		
Secondary Roads: Pavement Gravel or Earthen	28.33	1.15%	31		
Railroad Structures	10.18	0.41%	7		
Bridges/Abutments/Culverts	0.37	0.02%	21	60.38	2.45%
Category 8: Anthropogenic Uses					
Buildings/Facility	32.76	1.33%	26		
Paved Areas/Outdoor Storage	13.23	0.54%	12		
Fill/Excavations/Sludge	20.32	0.82%	13		
Ponds and Wastewater Impoundment	23.77	0.96%	22		
Water Conveyance/Control	6.94	0.28%	42	97.02	3.93%
Grand Totals	**2466.11**		**1330**		

Table 2.3 compares the relative percentages of each cover category between the entire study area and the lands within PORTS lands only. The within-PORTS-only statistics were developed using by digitally extracting only the study area within the presumed current property boundary using the boundary polygon available as a GIS feature in 2012. The relative composition of cover categories is not assessed separately for areas outside the PORTS lands. However, the large differences for the Mature Upland Forest and the Agricultural Uses categories would only be expected to increase in magnitude.

Table 2.3 Habitat/ Land Use Categories Comparison between Study Area and within PORTS Lands Only as Percentages of the Total Areas

Category	Study Area	PORTS Only	Difference
Category 1: Surficial Geologic Features	0.48%	0.45%	-0.03%
Category 2: Mature Upland Native Forest	36.33%	45.95%	9.62%
Category 3: Wetlands	1.24%	1.55%	0.31%
Category 4: Successional Uplands	26.78%	22.68%	-4.10%
Category 5: Agricultural Uses	16.49%	1.62%	-14.87%
Category 6: Maintained Vegetation	14.70%	21.37%	6.67%
Category 7: Transportation Features	1.80%	2.45%	0.65%
Category 8: Anthropogenic Uses	2.18%	3.93%	1.75%

2.1 Existing Vegetation Habitats and Land Use Classification

2.1.1 Category 1: Surficial Geologic Features

These are naturally occurring non-vegetated and non-anthropogenic features created and maintained through water flow and related mass wasting events. There were two types of natural, non-vegetated features delineated for this study that are likely to be generally self-maintaining by surficial processes.

2.1.1.1 Natural Stream

This class includes natural and naturalized stream channels with generally exposed water surfaces with rocky and gravelly substrate equal to or greater than 20 feet in width. Within the present delineation product, this primarily includes Little Beaver Creek and a few of its major tributaries, and Big Run.

2.1.1.2 Rock Outcropping

This class includes sandstone and shale bedrock exposed by flood-driven erosion along the left descending bank of Little Beaver Creek, just south of the Fog Road bridge and along much of the toe of the embankment of the closed sludge basins. Similar areas that are below minimum mapping unit area can be found along many valleys and on highly eroded ridge tops.

2.1.2 Category 2: Mature Upland Native Forest

Well-distributed, abundant rainfall and a mesic soil temperature regime assure the prevalence of a forested biome at this location. This cover category is characterized as “upland” to differentiate it from wetland forest discussed elsewhere. There were four upland forest communities observed and mapped in this portion of the study area composed of species considered to represent the mature native assemblage within disturbance-free periods that range in duration from more than 50 and less than 200 hundred years in duration. Both broad-leaved deciduous and needle-leaved persistent physiognomies are represented, with the category comprising more than 36 percent of the study area. The location and distribution of the types are strongly affected by topographic position and solar aspect, as these factors influence soil moisture balance and evapotranspiration budget during the growing season. The composition of these types, affected by time and interspecies competition, varies with stand age. Deciduous communities are composed of more than 50 woody, canopy-dominant species. The needle-leaved community form is nearly monotypic; dominated by Virginia pine (*Pinus virginiana*).

2.1.2.1 Oak-Hickory Forest

This forest type is composed of several species of oak (*Quercus*) and several species of hickory (*Carya*). The common dominant oaks include black oak (*Q. velutina*), white oak (*Q. alba*), shingle oak (*Q. imbricaria*), chestnut oak (*Q. prinus*) and northern red oak (*Q. rubra*). Hickories are represented by shagbark (*C. ovata*), pignut (*C. glabra*), mockernut (*C. alba*), red hickory (*C. ovalis*) and bitternut (*C. cordiformis*). The analysis of field sampling data revealed that sugar maple (*Acer saccharum*) comprises as much as 20% of this classification. Several species found in the Mixed Mesic forest (Section 2.1.2.2), including black cherry, hackberry and black gum also occur frequently. A relatively dense sub-canopy composed of serviceberry (*Amelanchier arborea*), sassafras (*Sassafras albidum*), sourwood (*Oxydendron arboreum*), hop-hornbeam (*Ostrya virginiana*) and flowering dogwood (*Cornus florida*) is common. Ground cover is composed of a greater representation of vines and low shrubs than herbs, many of which bear fruit important to wildlife.

Oak-Hickory forest occurs most frequently on south and west facing slopes, dry ridge tops and on flats with well-drained to excessively-well-drained soils. These stands range in age from 60 years to more than 130 years. Stem diameters are typically greater than 12 inches diameter-at-breast-height (dbh) and may range to greater than 50 inches for some relict fencerow and inaccessible valley bottom specimens. Diameter and height are usually not direct correlates with increased age of a stand due to the effects of xeric conditions on growth rates.

2.1.2.2 Mixed Mesic Forest

This grouping of species (sometimes called "mixed mesophytic") is highly diverse and may include all of the species found in both the previous and the following forest types, along with many shade-tolerant small trees and tall understory shrubs. This type is found on moist north and east facing slopes and on flats; generally above floodplains. Tulip poplar, American beech (*Fagus grandifolia*), basswood (*Tillia americana*), black gum (*Nyssa sylvatica*) and sugar maple (*A. saccharum*) are often dominant. Wild black cherry (*Prunus serotina*), northern hackberry (*Celtis occidentalis*), a mixture of oaks and honey locust (Gleditsia triacanthos) are common. Sycamore and elms are found along crevices, seeps and springs. The understory is populated with small trees and shrubs including ironwood (*Carpinus caroliniana*), serviceberry (*Amelanchier arborea*), blackhaw (*Viburnum alternifolium*), and various blueberry shrubs (*Vaccinium* spp.). The profusion and diversity of spring wildflowers reaches its apex in this habitat type. Trunk diameters of canopy dominants range from 8 to 40 inches, with the major distribution in the 16-20 inch range. Stems are often straight due to competition for light during growth. Canopy heights vary from 60 to nearly 100 feet, with many specimens in the 80-foot height group.

2.1.2.3 Bottomland Hardwood Forest

This forest type occurs in flood plains, in valley bottoms, along streams, at the toe of north-facing slopes and in moist ravines. This forest type is occasionally flooded but the duration of soil saturation is brief. The dominant tree species prevalent with this type include American sycamore (*Plantanus occidentalis*), American elm (*Ulmus americana*), red elm (*U. rubra*), green ash (*Fraxinus pennsylvanica*), box-elder (*Acer negundo*) and red maple (*A. rubrum*). Tulip poplar (*Liriodendron tulipfera*), shagbark hickory (*Carya ovata*) and cottonwood (*Populus deltoides*) are occasionally dominant. This forest type supports many of the larger trees in the study area. Mean trunk diameters range from 12 to 30 inches. Some specimens of sycamore exceed 60 inches dbh and rise more than 150 feet. Some tulip poplars and cottonwoods often exceed this height. These stands, due to their difficulty of access for timbering, may be the oldest stands, with the larger specimens with ages ranging toward 200 years.

2.1.2.4 Native Pine Forest

Native pine forests are strongly dominated by Virginia pine (*P. virginiana*), with an accompanying low diversity understory dominated by greenbrier (*Smilax* spp.) and invasive honeysuckle (*Lonicera* spp.). This type appears to prevail on ridge tops where oligotrophic (low-nutrient availability), eroded soil conditions have resulted from many decades of over-grazing and subsistence tillage. Native pine stands support relatively straight-stemmed specimens (indicating cohort competition) with trunk diameters ranging from 4 to 14 inches. Ages range from 30 to more than 60 years.

2.1.3 Category 3: Wetland Habitats

Wetland habitats occur in locations that retain water at or near the surface continuously for more than 30 days during the local growing season (Environmental Laboratory 1987), and as result sustain low soil oxygen concentrations (anaerobiosis) that slows woody plant growth and favors species in general with various structural and physiological adaptations to the low oxygen conditions. Wetland communities comprise less than 2 percent of the study area as mapped. Many were found to be smaller than the minimum mapping polygon or invisible under forest cover and thus, not all areas qualifying as wetlands are represented.

Relatively few plants can endure prolonged anaerobiosis. Those that can are classified as hydrophytes (*water-loving* plants). The longer the period during the growing season that a wetland hydrologic regime persists, the fewer number of species compose the plant community. Locations with near-perennial soil saturation often support marsh monocultures dominated by cattail (*Typha*), rush (*Juncus*, spp.), spike-rush (*Eleocharis* spp.) or other members of the sedge family (Cyperaceae). Because of wetland hydrology, the development of vegetation habitat differs from surrounding portions of the landscape with better drainage, creating a separate seral pathway to reaching climatic climax known as hydrarch succession. Hydrarch succession occurs due to changes in the hydrologic regime, assuming a process wherein open basins supporting submersed vascular vegetation and algae gradually fill-in with soil materials and vegetal debris proceeding to accumulate from the edges inward. Gradients of inundation or soil saturation occur from the deepest to the shallow parts of a basin, providing conditions suitable to a changing array of species, until the basin has filled entirely and become a non-wetland habitat.

While this process occurs as a general principal, it may require a period similar to that for which it takes a hilly region to become a plain. In practice, hydrarch succession is interrupted by surficial processes such as stream erosion and aggradation, mass wasting, spring persistence; biological processes such as root-throw, beaver activity, large grazing animals and burrowing animals; and very frequently by anthropogenic activity; influences which occur at a much higher frequency to create or destroy wetland hydrologic conditions.

Depending on the persistence of the hydrologic regime, with consideration for the life cycles of the local potentially occurring species, the climatic climax vegetation may thus persist as an herbaceous stage, a shrubby stage or a forested stage for very long periods within this study area. Odum (1971) referred to this as a *plagioclimax* or *hydrosere*. Wetlands found to occur within the project site are characterized using the methods of Cowardin *et al* (1987), which segregate using a systematic and structural classification. Systematically, all the wetlands mapped for this project area are classified as palustrine. Palustrine wetlands are those associated with shallow, topographically retained basins for which the wetland hydrological regime is principally sustained direct precipitation, local surface runoff, small springs and poorly permeable soils, such as fen, marsh and swamp. The majority of wetlands not associated with constructed pond fringes are spring-driven. In contrast, lacustrine wetland hydrology is sustained by the level of an adjacent lake. Riverine classed wetlands that persist along the Scioto River two miles to the west and may extend into the far western edge of the study area, are sustained by mean water elevations and seasonal flooding in the river channel.

2.1.3.1 Palustrine Forested Wetland

This class of wetland is dominated by hydrophytic trees and saplings, with an understory of shade-tolerant shrubs and sedges. The ground surface is characterized by the hummock-hollow features that occur in areas flooded during the early part of the growing season and only saturated to the surface in the hollows for the remainder. The larger mapped stands, occurring along the right descending bank floodplain of Little Beaver Creek, appear to sustain wetland hydrology by a combination of spring flood retention behind the natural levee and springs along the slope toes to the east of the stand. Dominant trees include river birch (*Betula nigra*), black willow (*Salix nigra*), red maple, green ash, swamp chestnut oak (*Q. michauxii*) and pin oak (*Q. palustris*). Birch range from 6 to 18 inches dbh, with the rarely occurring oaks varying from 20 to 30 inches in diameter. Swamp dogwood (*Cornus amomum*), southern arrowwood (*Viburnum dentatum*) and spicebush (*Lindera benzoin*) provide a frequently occurring shrub layer that is often edged out by the invasive multiflora rose that has densely colonized the hummocks.

2.1.3.2 Palustrine Scrub/Shrub Wetland

This class of wetland is characterized by the presence of persistent surface saturation provided by runoff from surrounding uplands or the backwater effects of ponds. The majority of these types exist from directed or inadvertent anthropogenic activities such as basin construction, ditching and concentration of surface runoff from landscape grading. Dominant hydrophytic shrubs and saplings include black willow, sandbar willow (*S. interior*), swamp dogwood, and swamp rose (*Rosa palustris*). The thin canopies of these species allow a dense ground cover of sedges, rushes and diverse hydrophytic herbs.

2.1.3.3 Palustrine Emergent Wetland

In this wetland class, hydrophytic herbs and graminoids (grass-like plants) dominate the small depressions and pond fringes in conditions similar in origin to those for shrub-scrub wetlands. Species diversity is very high along a gradient parallel to the topographic grade, but non-diverse along elevation bands parallel to a standing water feature. Species groupings observed were typically composed of well-developed perennial stands rather than annual species, suggesting that they had persisted for several years to decades.

2.1.4 Category 4: Successional Upland Communities

Successional habitats presently occupy a major portion of both the PORTS lands and the greater study area (approximately 27%). These provide superior foraging, shelter, concealment, nesting and denning opportunities for ground birds such as grouse and quail and for quadrupeds such as whitetail deer. Successional processes leading to an inevitable and ultimately prolonged dominance of trees in this biome is assumed to eliminate the majority of these habitats in a matter of years to decades, if not sustained through re-disturbance (such as mowing). Successional habitats are segregated into two major types based on the degree and kind of disturbance that has occurred. Successional native communities are distinguished as those that have developed since the last relatively light disturbance (mowing, light grading, and plowing or discontinued herbicide application) through natural processes. Typically, the propagules sources were extant in the soil or were derived via natural pathways from adjacent native sources; they were not planted. Invasive species both native and alien may be common or even dominant but the soil had not been subjected to egregious perturbations resulting from excavation, heavy grading or filling. Segregation of both native ruderal and successional habitats is based on major physiognomic canopy conditions (i.e. tree, sapling shrub, herb and vine).

Ruderal succession is the term used to characterize habitats that have been subjected to extreme soil disturbance such as occurs from borrow activities, deep grading, grubbing, and filling; but also from repeated herbicide application and mowing. The mowed-maintained type defined under anthropogenic uses could also be grouped under this category. Ruderal successional areas frequently have been seeded or planted due to a paucity of residual native propagules. The resulting habitats are distinguishable by a dominance of odd groupings of native hybrid species, annual and perennial alien species, early-successional natives with wind-born propagules and natives and aliens resistant to both herbicides and mowing.

Because of the scale of interspersion of herbaceous and woody covers, delineation of polygons required a degree of art and visual acuity to distinguish dominance by a particular canopy structure. It is assumed that the boundary edges between some of these types will change year to year as growth and woody vegetation canopies expand and suppress shrub and herbs.

2.1.4.1 Successional Forest

This type includes forested stands with closed canopies dominated by tree-forming woody species with breast-height stem diameters in the 2 to 12 inch range. Dominant stem diameters are skewed toward the lower end of the range. The understory is generally scant except in spring before canopy leaf emergence. Much of the successional forest in this study area is strongly dominated by red and sugar maple saplings, which given their positions surrounded by mesic forest, may have received a steady rain of wind-born seeds from the highly prolific and easily transported *Acer* genus.

2.1.4.2 Successional Scrub

Shrubs and saplings dominated by native species progressively invade areas of Oldfield succession (Section 2.1.4.3), as particularly perching birds import the fertilized seeds of berry producing trees and shrubs. While some of the many invasive species, such as multiflora rose, privet (*Ligustrum spp*.), shrubby St. Johnswort (*Hypericum prolificum*) and the shrub and vining honeysuckles (*Lonicera spp.*), may become established and even dominant, an array of native trees and shrubs appear in this phase of succession. Dominant native shrub-stage species include flowering dogwood, black gum, sassafras, black locust (*Robinia psuedoacacia*), hawthorn (*Crateagus spp*.), buckthorn (*Rhamnus spp*.), serviceberry, spicebush and wild grapes (*Vitis spp.*). Initially bushy and ground concealing due to omnidirectional light availability, height and increasing competition raises straighter stems and leads to a closed canopy of woody vegetation that suppresses shorter herbs and grasses. During growth, other animal and wind vectors will have delivered nuts from oaks, hickories, walnuts (*Juglans spp.*) and abundant maple seed, which provide the growing stock for the successional forest.

2.1.4.3 Oldfield Successional

This type is composed of primarily native herbaceous tall herbs and grasses that emerge in areas lightly perturbed areas by tillage, haying and grazing, for example. Dominant species often include herbs such as goldenrods (*Solidago* spp.), thoroughworts, such as joepye-weed (*Eupatorium* spp.), dogbane (*Apocyanum* spp.) and ironweed (*Vernonia* spp.) and tall grasses, such as Johnson grass (*Sorghum halepense*), Timothy (*Phleum pratense*), Orchardgrass (*Dactylis glomerata*), and on poorer soils; broom-sedge (*Andropogon virginicus*).

2.1.4.4 Ruderal Shrub/Sapling

This type is comprised of both native and invasive saplings, shrubs, vines on graded soils and particularly areas both heavily graded and subject to formerly frequent herbicide application such as railroad peripheries. Signature canopies are generally the same wind-born natives such as sycamore, elm and cottonwood that are usually the first to occupy barren alluvial materials along river deposition bars. Japanese honeysuckle (*L. japonica*) is usually strongly dominant.

2.1.4.5 Ruderal Scrub

This type is similar to the Successional Shrub/Sapling stage discussed above but strongly dominated by alien invasive shrubs and vines on drastically disturbed soils. Multiflora rose, autumn and Russian olive (*Elaeagnus* spp.), common privet and Amur honeysuckle (*Lonicera maackii*) struggle for space with Japanese honeysuckle (*L. japonica*) and trumpet-creeper (*Campsis radicans*). Often invasive natives such as blackberry (*Rubus* spp.), shrubby St. Johnswort, greenbrier (*Smilax* spp.), hawthorn and black locust are mixed; their thorns making some of these areas nearly impassable.

2.1.4.6 Ruderal Successional

This type is similar to Oldfield succession but occurs on drastically disturbed substrates. Excavated areas that have been seeded with an array of typical "restoration" non-native grasses and legumes dominate the surface. When Kentucky fescue (*Festuca arundinacea*) and Sericea lespedeza (*Lespedeza cuneata*) are planted, the result is often a near-permanent plagioclimax. Another identifiable feature of this type is the dominance by plants in near-monotypic densities by species that normally occur in vastly different environmental conditions. As an example, the borrow pit northeast of the shooting range is vegetated by dense stands of species from the genus *Bidens*, which typically occurs in areas with long-term soil saturation; emergent wetlands.

2.1.5 Category 5: Agricultural Land Covers and Uses

Land uses imposed by human land managers affect land cover and participate in the development of a delineation strategy as both uses and vegetation covers. Land use designations include the apparent present uses, based on the date of the imagery and the timing and intensity of supplementary field observations. Lands within the PORTS site are generally managed to support the designated DOE mission, however most of the project study area is used passively, that is; unmanaged on a routine basis and allowed to succumb to natural processes. Lands under active use or management observed in this project study area include the following types.

This land use designation includes multi-acre parcels under current use for production of biological products. General features include the presence of regular field shapes that are often occupied by rows of planted vegetation. These are important features within the project study area, outside of the DOE-owned reservation, and can include minor strips that have encroached into the reservation fringes. Planted pine, included in this category, are occasionally extensive but are unlikely to be harvested and sold as a product under the present ownership and management scheme. This category accounts for approximately 16 percent of the study area.

2.1.5.1 Planted Pine

Stands of planted pine are distinguishable by the row signature and the usual evenness of height. Stands near DOE facilities outer boundaries were probably planted as screens. Most stands are uniform in species, generally white pine (*Pinus strobus*), and age at approximately 50-60 years (approximately the age of facility construction), however three species have been noted in either monotypic or mixed stands. Extensive stands of planted pine along the northeast side of the project study area are, along with white pine, composed of pitch pine (*Pinus rigida*) and red pine (*Pinus resinosa*) aged from 30 to more than 70 years and were probably established for wood products. Trees are generally 40-60 feet in height and range from 6 inches to greater than 24 inches dbh, with median diameters near 12 inches. Some of these stands may be associated with former ownership and management by a regional paper company.

2.1.5.2 Hay/Pasture

Large mowed areas with dense graminoid and herbaceous vegetation lacking regular patterns from farm machinery or the evidence of pasturing were mapped as hay fields. Pasture or paddock fields will have evidence such as a generally poor soil and vegetation appearance, the presence of feeding and watering structures, sheltering structures and often patterns of worn trails. Occasionally, the pastured animals themselves are visible. Crop fields display the characteristic signature of mechanical farming. Images acquired outside the growing season generally present barren soil. Those obtained during the growing season are densely vegetated; however, the row lines and regularities of the farming practices are clearly visible during any season.

2.1.5.3 Row Crop

These features are apparently tilled annually to support the local crop rotation (corn-beans) agricultural economy. Parallel tilling row lines are visible in the dormant season. Regular planted rows are visible in the growing season.

2.1.6 Category 6: Maintained Vegetation

This feature type includes any areas that are routinely maintained by either mowing, as along roadways and lawns, or by fire, as performed to sustain the artificial prairie atop the former sludge pond.

2.1.6.1 Mowed Grass / Lawn

This class includes areas frequently mowed throughout the growing season along roadways, on the faces of earthen embankments. This class, accounting for approximately 5.5 percent of the study area, becomes more dominant upon closer approach to the PORTS central industrial facility. This classification also delineates the edge of the managed lawn, yard and use area.

2.1.6.2 Planted Restoration

This class of cover is used to characterize and represent vegetation that has been intentionally planted to achieve a specific goal, such as to mitigate erosion of sensitive fill areas. These areas often require little, but some routine maintenance and may have different outcome goals. These areas can contribute to the ecological function of the area to various degrees.

2.1.6.3 Cemetery

Several active cemeteries occur within the study area, but outside of the PORTS lands. Cemeteries within the PORTS lands were difficult to identify due to their very small size and they are not easily noted on imagery due to the masking effect of large trees. As result, cemetery boundaries were imposed as land use features using a GIS feature created for a plan entitled, "Department of Energy Portsmouth Gaseous Diffusion Facility Cultural Resources Management Plan" prepared by the ASC Group, Inc. in a report dated November 25, 1997 (ASC 1997).

2.1.6.4 Powerline Corridor

Powerline corridors are a maintained–managed plant community dominated by various successional stages of mostly native mixed, trees, shrubs, saplings and herbs that have been shaped into diminutive form by occasional mowing and frequent aerial herbicide application. Variability in species composition and structural development is controlled by the time since the last suppression action.

2.1.6.5 Domestic Lawn and Appurtenances

Residential usage is common along the fringes of the study area but absent within the PORTS reservation. Active residences mapped are distinguished by driveways, the presence of automobiles, a maintained lawn, out buildings and other fabricated objects.

2.1.7 Category 7: Transportation Features

Transportation corridors and features offer both beneficial and undesired values to wildlife. They may function as barriers or hazards to some species at some times, or travel ways and foraging opportunities to others. Clearly, they also provide frequent opportunities for undesired human-animal contact. Road surfaces provide little nesting habitat, locking the soil away from biological processes.

2.1.7.1 Primary Road: Pavement-Asphaltic

Primary roads are paved, rigid linear surfaces constructed and maintained to carry traffic through and to main facilities within the site. Most appear to be surfaced by bituminous or concrete asphalt. There was no attempt to distinguish surface compositions between pavements. These are delineated along the edge of the asphalt using the painted white lines as edge guides. Berms and road fill are classified as "mowed-maintained", fill, gravel or ruderal, depending on the width and the ability to distinguish vegetation.

2.1.7.2 Secondary Road: Pavement-Graveled or Earthen

Secondary roads appear to be gravel surfaced and used to access interior DOE site features and activity areas on a frequent to infrequent basis. The contrasting edge of the gravel pavement is used to delineate these features, resulting in a frequently irregular edge, as gravel placed for the road surfacing cannot be distinguished from gravel fill placed to maintain the grade. Earthen paths are non-surfaced roads that have been created by light grading or maintained by simple use. Often they are definable by the two tire tracks worn into surrounding low vegetation. Berms often appear mowed, since any gravel edging has become invisible under persistent low vegetation.

2.1.7.3 Railroad

The entire railroad ballast structure and tracks are mapped as linear polygons. Vegetation along these is likely to be chemically suppressed on a regular basis and mapped as ruderal.

2.1.7.4 Bridge/Abutment/Culvert

Bridges are delineated because they often provide safe travel corridors for site quadrupeds and aquatic species. Knowledge of their location will be used for wildlife usability assessments and the development of wildlife management plans. Abutments and culverts play a small role in ecological functionality; however can become important elements in the hydrologic regime of the area.

2.1.8 Anthropogenic Uses and Features

This classification includes structures or features that have not been appropriately classified into a previous category and are larger than the minimum mapping scale for the study area. This category includes hardscape structures or features (excluding domiciles) observed.

2.1.8.1 Building/ Facility

Any building or facility found within the DOE property has been mapped and can be considered to hold some mission-based purpose. There are few within this limited project extent. Buildings mapped outside of the DOE property boundary are limited to larger structures and exclude apparent domiciles.

2.1.8.2 Paved Area/Outdoor Storage

Paved areas included those surfaced with gravel, concrete or asphalt. The designation “asphalt” is used for apparently smooth, hard surface paved areas. Paved areas include permanent outdoor storage areas, parking areas and maneuvering areas near industrial buildings, but are not roadways for vehicular traffic. Some of these features may have barren soil or gravel ground surfaces with bulk materials piles or orderly arrangements of objects of various sizes. This type of material storage area may be temporary and related to construction activity observed in the imagery.

2.1.8.3 Fill/ Excavation/Sludge

This class is identified by barren soil piles and/or excavations. These are generally along roads and may be temporary disposal or borrow sites. A number of vegetated fill and excavation areas are noted throughout the project area but are mapped as ruderal vegetation in various stages of succession.

White, limey sludge is distinctly visible where it occupies an approximately 12 acre portion of the large pond in the northeastern quadrant of the PORTS reservation. This material is apparently non-toxic; numerous large, easily observed (due to the low-turbidity water column) predator fish observed during field sampling suggest the presence of a fully structured aquatic ecosystem in the surrounding basin.

2.1.8.4 Pond and Wastewater Impoundment

All impounded water bodies observed within the study area are constructed features. The water-earth interface at the instant of image capture is the basis for polygon delineation and thus is subject to some seasonal change. Vegetated fringes are generally mapped as wetlands. Notwithstanding the anthropogenic origin of these structures, they provide important benefits to native wildlife.

2.1.8.5 Water Conveyance/Control Structure

Several earthen embankments associated with active and closed ponds are notable throughout the site. Spillways in association with the earthen embankments and dams included in this class are mostly large pond spillways, concrete channel linings, and large concrete headwalls. Large rock (1 to 4 feet in diameter) has been liberally employed for embankment stabilization, shoreline protection and channel erosion prevention throughout the PORTS site as well. Rip-rap accounts for nearly 3-acres of ground coverage in this limited delineation.

2.2 Mapping Process

This mapping product, a delineation of habitats and land uses within the approximately 5300 acre study area, was prepared through "heads-up" digitizing and extensive "field-truthing." Digitizing was performed at scales of 1:300 to no more than 1:1000, with an expected accuracy of the polygon edges less than 5 feet. The data were processed using a cluster tolerance of 1 foot and, as a result, data are expected to be precise to 2 feet. Any vertices within 2 feet of another would become one vertex. Boundaries for the classifications were initially captured by digitizing edges visible on aerial imagery. Field sampling of habitat characteristics and specific quality control sampling conducted during the delineation process were used to refine and validate the developing habitat delineation. Sample points were captured using sub-meter accuracy global positioning system (GPS) equipment and converted to on-screen point files.

Vegetation plot coordinates were captured using a Trimble GeoXH operated using ArcPad 10 software and the GPS Correct Software from Trimble. This platform is capable of real-time differential processing, using sources such as the wide area augmentation system to sub-meter accuracy under leaf-off or open sky conditions with the best satellite geometry. Following field collection, digitally captured data were downloaded directly to the database using Esri‟s distributed geodatabase workflow and the ArcPad data manager. Prior to fieldwork, data were checked out to the device, which included supplemental field collected data. This ensured that, while in the field, field technicians had access to the most up to date information.

Software used for data creation was Esri‟s ArcGIS 10 with Spatial and 3D Analyst extensions. Post data-creation summary information was calculated using select query language (SQL) spatial queries from a database external but accessible to the GIS database.

2.2.1 Aerial Imagery and LiDAR

The primary aerial imagery used for the digitization process included:

- Color Aerial Image was provided by the Department of Energy captured in the fall of 2007. The image has a resolution of 6 inches per pixel width and height, or 24 square inches per pixel. In this image, trees are in a partial state of leaf on, or leaf off, depending on species.
- Color Aerial Image was obtained from the Ohio Geographically Referenced Information Program (OGRIP). The image is part of the Ohio Statewide Image Program (OSIP) and was captured for Pike County in spring of 2007. This image has a resolution of one foot per pixel width and height, or 1 square foot per pixel and is leaf off (OSIP 2007).
- Color Aerial Image obtained from the National Agriculture Imagery Program (NAIP) captured in the summer of 2011. The image has a 1-meter resolution with a 1-meter pixel width and height a total pixel area of 1 square meter. This is a leaf-on image.
- Color Infrared Image obtained from OSIP and captured in leaf-off condition on December 3, 2008. The image has a 3-foot pixel resolution with a height and width of 3 feet and a total area of 9 square feet.

In addition to aerial imagery, supporting data included Light Detection and Ranging (LiDAR) derived canopy heights. LiDAR files for the 49 grid cells encompassing the facility and the project study area were obtained from OSIP‟s data download tile viewer (OSIP 2007). LiDAR was obtained at the same time as the spring, 2007, OSIP imagery.

Digital elevation models generated from the LiDAR were used to create a series of secondary GIS products that were used as overlays to refine understandings of imagery textures. These were used to define classification edges, subject to field verification.

2.2.2 Canopy Height above Ground

LiDAR files were imported into two multipoint shapefiles using Esri 3D Analyst, one for first returns and one for last returns. Inverse distance weighted interpolation using up to 12 closest points was performed to create raster cells of 2.5 x 2.5 feet for each shapefile. The difference between the two interpolated rasters was calculated to represent vegetation canopy heights and was used as an aid in habitat classification.

The heights of canopy vegetation above the ground surface was created using LiDAR to prepare a canopy elevation shapefile. This required subtracting bare ground elevation from raw surface elevations. Using the new vegetation surface and the new bare ground surface, the various heights of the vegetation was usable to compare with other ecological parameters including stand age (taller trees are older trees), average tree bole diameter (taller trees are larger in diameter than shorter trees), habitat structural complexity (taller trees groupings represent various size, age and mortality groups with greater habitat opportunities than shorter trees).

2.2.3 8-Direction Aspect Map

Aspect is the compass bearing that a slope faces. Aspect was derived using Esri's ArcGIS Spatial Analyst extension using a digital elevation model obtained from OSIP with a 2.5 foot resolution. This was then reclassified into the standard 8 cardinal directions based on True North. These are North, Northeast, East, Southeast, South, Southwest, West, and Northwest.

2.2.4 Slope Map

Slope is a scalar representation of how much elevation change occurs over a unit of distance. Slope is generally calculated as a grade, by fitting a right triangle to the surface, grade is the tangent of vertical change divided by the horizontal distance. Slope was derived using Esri's ArcGIS's Spatial Analyst extension using a digital elevation model obtained from OSIP with a 2.5 foot resolution. The result is the grade, or slope in degrees, in the steepest direction at each 2.5 x 2.5 foot location.

2.2.5 Drainage Network and Watershed Features

A line feature was created using the 1-foot interval topography product. Stream segments were attributed by length and drainage area to the first joining vertex. A second watershed polygon feature was also created and attributed by area upstream of the first intersection. The ability to later intersect with other features; habitat type, tree height, soil type, slope, provided visual controls for digitizing and was used to guide field sampling.

2.2.6 Other Data Sources

2.2.6.1 Field Samples

This includes all the data collected in the field and digitally entered as described elsewhere in this document. This dataset was used to calculate many of the reported metrics and summary information that describes the condition and quality of study area habitats.

2.2.6.2 Habitat Cover

The polygon layer digitized as part of this project encompasses the entire study area and provides habitat classifications. Using spatial intersections, this dataset provides the habitat classification for every plot and contributes to summary information reported for the study area and habitat information.

2.2.6.3 Study Area

The polygon representing the study area as defined at the start of this project is a geometric union of the DOE Property boundary and a one-mile buffer of Perimeter Road. The western edge of the study area was limited to the extent of Wakefield Road (Pike County 44).

2.2.6.4 USDA PLANTS Database

The United States Department of Agriculture (USDA) maintains and publishes a standardized database of plant species. The PLANTS database was used for auxiliary data in analysis as well as an authoritative source of species information and species codes.

2.2.6.5 Ohio Vascular Plants Database

Published by the Ohio EPA, the vascular plants database was used to obtain the coefficient of conservatism (C of C), which was used in the calculation of the Floristic Qualitative Assessment Index (FQAI).

2.2.6.6 PORTS Property

The property boundary provided by DOE was used to define lands on the PORTS reservation from other lands within the study area. A number of changes and revisions were made to this feature to account for more recent land acquisitions and disposals.

2.3 Field Data Collection

Habitat and land use classifications were based on both remote sensing observations and field sampling. Vegetation data was collected using a stratified sampling method applied at selected sites within each homogeneous community type encountered. Data were recorded on a prepared form printed on water and tear-proof paper. Sampling point (plot) selection was based on both remote sensing and field observation of vegetation groupings (or communities), considering the dominant life form (tree, shrub, herb, etc.), the relative size of the oldest dominant vegetation, the dominant species and the relative position along a hydrological gradient (uplands or wetlands), as identified using aerial photographs and field observations.

Circular sample plots were field selected within the apparently homogeneous vegetation associations. Sampling continued within a habitat until no new dominant species/life forms were found. Sampling data collected included characteristics of the woody and herbaceous vegetation and other physical characteristics, including soil within the rooting zone, drainage, topography, solar aspect and weather conditions. Sample field data sheets are included as Appendix F. Sampling methods, analytical procedures and materials are described in this section. Findings are presented in Section 3. Sample plots were GPS-located and the plot locations are shown in Figure 2.1. Quantitative vegetation sampling was conducted during the periods of May 1, 2011 through October 30, 2012. Figure 2.2 shows field equipment used during field sampling.

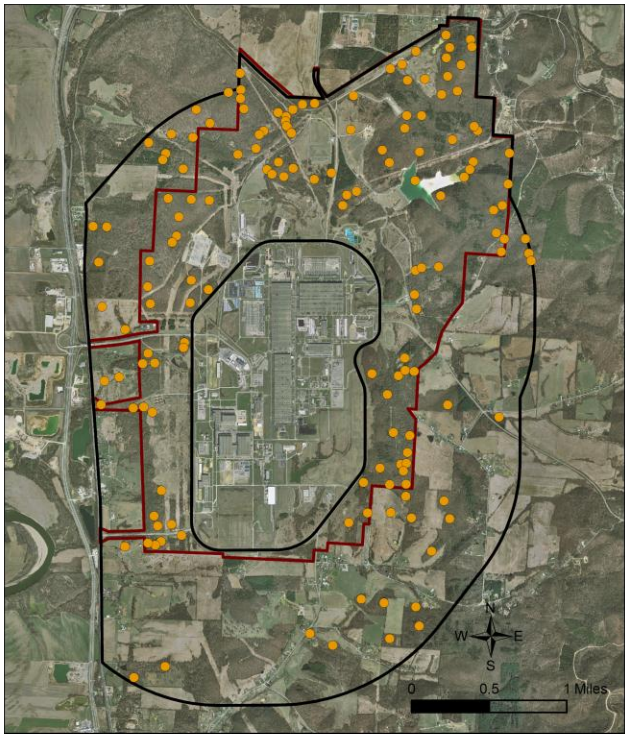

Figure 2.1 Sampling plot locations within the study area

Figure 2.2 Field equipment used during field operations at PORTS

2.3.1 Sample Point Setup and Sampling

Once sample plot locations were selected, a 12-inch deep soil core was extracted using a 1-inch diameter tube-type soil probe. A support rod was inserted into the soil hole that became the plot center. A rigid, calibrated pole was fixed to the rod and used for measurement of radial distances to establish the circular plot perimeter. A 10-factor Jim-Gem clear forestry prism (Figure 2.3), oriented vertically, was used to "read" the 10-meter plot radius from the calibrated center pole at multiple locations along the perimeter. Temporary pin flags were used to mark the perimeter at 12 or more locations, defining the area of the "master plot." The prism was used as necessary to check whether a specimen near the plot perimeter was within the sample plot. The north point of the master plot was identified by a flag of a different color than the other perimeter flags. The master plot was then quartered using a hand compass. A diagram of a sample plot is shown in Figure 2.4.

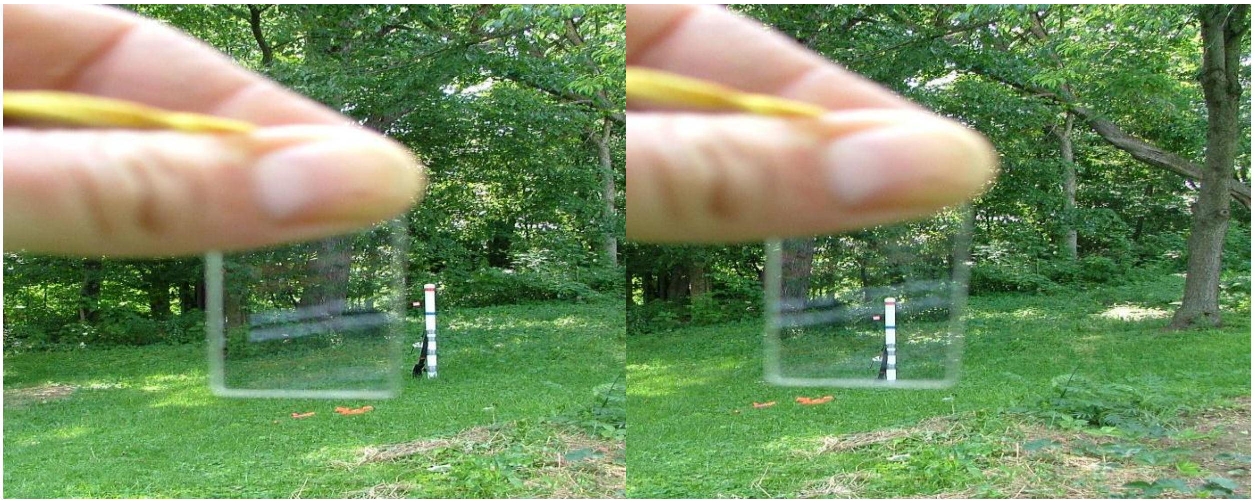

Figure 2.3 Forester's prism used to set up plot perimeter

Vegetation data was collected using a three-stratum nested quadrant method. Strata sampled included the canopy trees, understory shrub-sapling stratum and the generally herbaceous groundcover layer. Soil and hydrological data and other environmental conditions were simultaneously recorded within the 10 meter plot. Following sampling, perimeter flags were removed. A wooden stake inscribed with the plot number and date was inserted to mark the center point (see Figure 2.5), once the calibrated center pole and rod were removed.

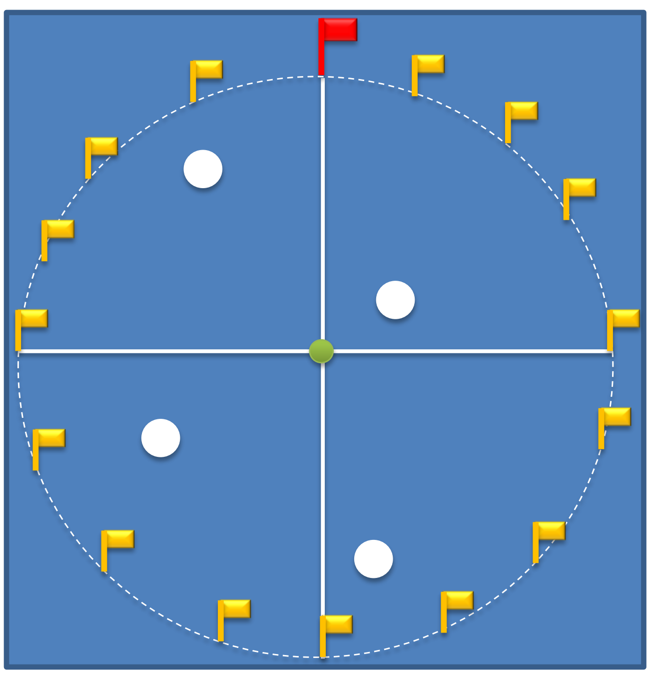

Figure 2.4 Plot set-up configuration

Figure 2.5 Setting stake to mark the center of sample plot

2.3.1 Woody Vegetation Sampling

Woody vegetation includes all tree, sapling, shrub and woody vine species. All stems occurring within the plot were recorded by species and diameter class. Trees and saplings were measured as single-stem woody vegetation greater than 1 inch diameter-at-breast-height (dbh) and greater than 4 feet in height. Trees and sapling were measured and recorded for the entire master plot. Shrubs and vines may be measured and recorded within one to all quarter plots, depending on density and uniformity. Shrubs included single stem woody vegetation less than 1 inches dbh, all single or multi-stemmed woody vegetation, woody vines greater than 2 feet, and less than 4 feet in height. Woody vegetation less than 2 feet in height was counted in herbaceous layer measurements.

Tree diameter was measured at breast height using a standard tree diameter tape as shown in Figure 2.6. Shrub diameter was measured at the point of all separate stems emerging from the soil using a Leonard stem caliper.

Tree age was assessed at each plot by ring count of extracted cores from 2 to 5 average-sized trees, taken at breast height using a Haglofs 3/16th inch No. 2 increment borer. Shrub age was assessed by cutting one to several average-sized stems near ground level and counting growth rings. Cores and stem sections were collected in the field and later mounted for sanding and inspection under magnification in the laboratory.

Figure 2.6 Using dbh tape to measure tree diameters during this study

2.3.2 Herbaceous Vegetation Sampling.

The estimated percent areal coverage for each herbaceous or woody species less than 2 feet in height were recorded separately in four 1-meter sub-plots, as shown in Figure 2.7. One sub-plot was stochastically located by blind throw in each quarter of the master plot. Life forms sampled included all vascular plants such as fern and fern allies, floating or rooted aquatic plants, grasses and grass-like plants, herbs, herbaceous vines and woody vines, shrubs and trees less than 2 feet in height. Herbaceous subplots were the inner area of a 1-square meter sampling frame. Coverage percentage increments were limited to 0.1, 0.5, 1, 2, 3, 5, 10, 15, 20, 30, 40, 50, 60, 70, 80, 90 and 100 for each species. Since the herbaceous layer was typically stratified due to variable species‟ light requirement and growth form, total subplot coverage often sums to greater than 100 percent.

Figure 2.7 Identifying herbaceous species within the sampling hoop

2.3.3 Other Habitat Observations

The following additional data was collected and used for habitat evaluation, habitat differentiation and may have a qualitative or quantitative expression. This data was also captured in the database, available for calculations and analysis.

- Woody Debris: Percent ground cover at a plot by dead woody debris, estimated by size class
- Duff and litter depth: Percent of leaf litter covering the ground surface within plot and average depth of litter
- Soil characterization to a depth of 12 inches (see Figure 2.8): Validation of the soil survey layer and the development of correlations between soil characteristics and habitats or species occurrence. As evaluated using USDA NRCS 2002 (Schoenberger et al. 2006)
- Hydrologic characteristics: A variety of measurements and observations to characterize the hydrologic régime of the plot or habitat type
- Soil drainage class: As evaluated using USDA NRCS 2002 (Schoenberger *et al.* 2006)
- Denning/nesting opportunities: This includes holes in logs and standing trees, rocky ledges, earth burrows and active dens and nests

Figure 2.8 Soil probe used to extract <12" surface soil samples

2.3.4 Data Transfer and Storage and Quality Control

2.3.5.1 Data Entry

In order to ensure that the information collected in the field on field forms was accurately entered into the database, a strict entry system was implemented utilizing an electronic entry form using Microsoft Access. A single form, embedded in the Access file, was used for a data entry. This form mimicked the field sheets as closely as possible to reduce confusion in data entry procedures. The exact relational data structure was modeled in Access, including data validation for all fields of all tables. This, combined with the data validation, greatly reduced errors in the process of digitizing the field data. Following data entry, the resulting tables were reviewed for quality and consistency prior to the data being used in further analysis (Figure 2.9).

2.3.5.2 Data Tables

2.3.5.2.1 Vegetation Sample Plot

Field data were collected in sample plots as described in the previous section. The vegetation plot table, *vegplot*, contains all the habitat variables collected and observed about each plot location, including landscape position, visible habitat features, date and time, weather conditions, dominant canopy structure, geomorphology, and comments.

The actual location of the vegetation plot was collected using a Trimble GeoXT and stored in a separate table named *PlotLocations* using the alphanumeric Plot ID.

2.3.5.2.2 Trees and Tree Cores

The size and species of each tree was recorded on the formatted field form for each sample plot location. Two or more trees representative of the entire plot were cored in the field. Resultant tree sample information was populated into two tables, *tree* and *treecore*. These tables relate to the vegetation plot table in a many-to-one relationship based on the Plot ID. Information collected for trees includes:

Plotid: The alphanumeric ID of the related vegetation Plot ID

DBH: The diameter-at-breast- height of the tree in inches

Health: Indicates if an individual tree was Healthy, Morbid, or Dead

Cored: A Boolean (1 or 0) variable indicating whether an individual was cored, where 1 = cored

Species: The alphanumeric species code provided by the USDA Plants Database

RingCount: The number of rings in the tree core to pith as a measure of tree age

Diameter Cored Tree: The diameter-at-breast-height of a cored tree in inches

Type: Either Core or Section, smaller trees were cut to get a complete cross-sectional disc, while larger trees were cored

2.3.5.2.3 Shrubs and Vines

The tables for shrubs and vines have identical structure. Each relate to the vegetation plots using the Plot ID in a many-to-one relationship. Due to the abundance of stems in these woody strata, stem counts were logged in size class brackets. These were measured at the base of the stem. The information gathered includes:

Plotid: The alphanumeric ID of the related vegetation Plot ID

Species: The alphanumeric species code provided by the USDA Plants Database

N: Where N is an integer in intervals of 25 up to 300. There are a series of numerical columns representing diameters categories. For example, 125 were used for diameters of 1.25 inches. The values in these columns are the number of stems whose diameter was closest, i.e. rounded, to this value. There is a column for every 0.25 inches up to 3.00.

2.3.5.2.4 Herb plots and Herbs

Up to four herb samples were taken at each vegetation plot using a stratified random sample. Samples were collected by tossing a circular square meter hoop into each of four quadrants of the entire plot. Total ground cover was recorded for each toss as well as the cover for each individual species observed within the ring. Two tables were created, one table for the herb plot, which relates in a many-to-one relationship to each vegetation plot based on the Plot ID. The herb table relates to the herb plot using a generated numeric HerbPlot ID.

Plot ID: The alphanumeric ID of the related vegetation plot

Quadrant: The quadrant of the vegetation plot in which the herb plot was captured NW, NE, SW, SE

PercCover: Percentage of vegetation covering the ground within the sample ring

HerbPlotID: The numeric ID of the related herb plot

Species: The alphanumeric species code provided by the USDA Plants Database

PercCover: The share of the total percent covers of each species within the sample ring

2.3.5.2.5 Soils

Soil samples were collected at each sampling location. These samples include the first several soil horizons up to 12 inches. The soil table stores the observations of these horizons and relates to the vegetation plot in a one-to-many relationship based on the Plot ID. Columns found in the soils table include:

Plotid: The alphanumeric ID of the related vegetation plot

Horizon: The vertical horizon of the soil profile

UpperDepth: The upper bound of each horizon, in inches, of the depth from the surface

LowerDepth: The lower bound of each horizon, in inches, of the depth from the surface

Other: Columns include Mottle Color, Class, Grade, Type, Size, and Consistence

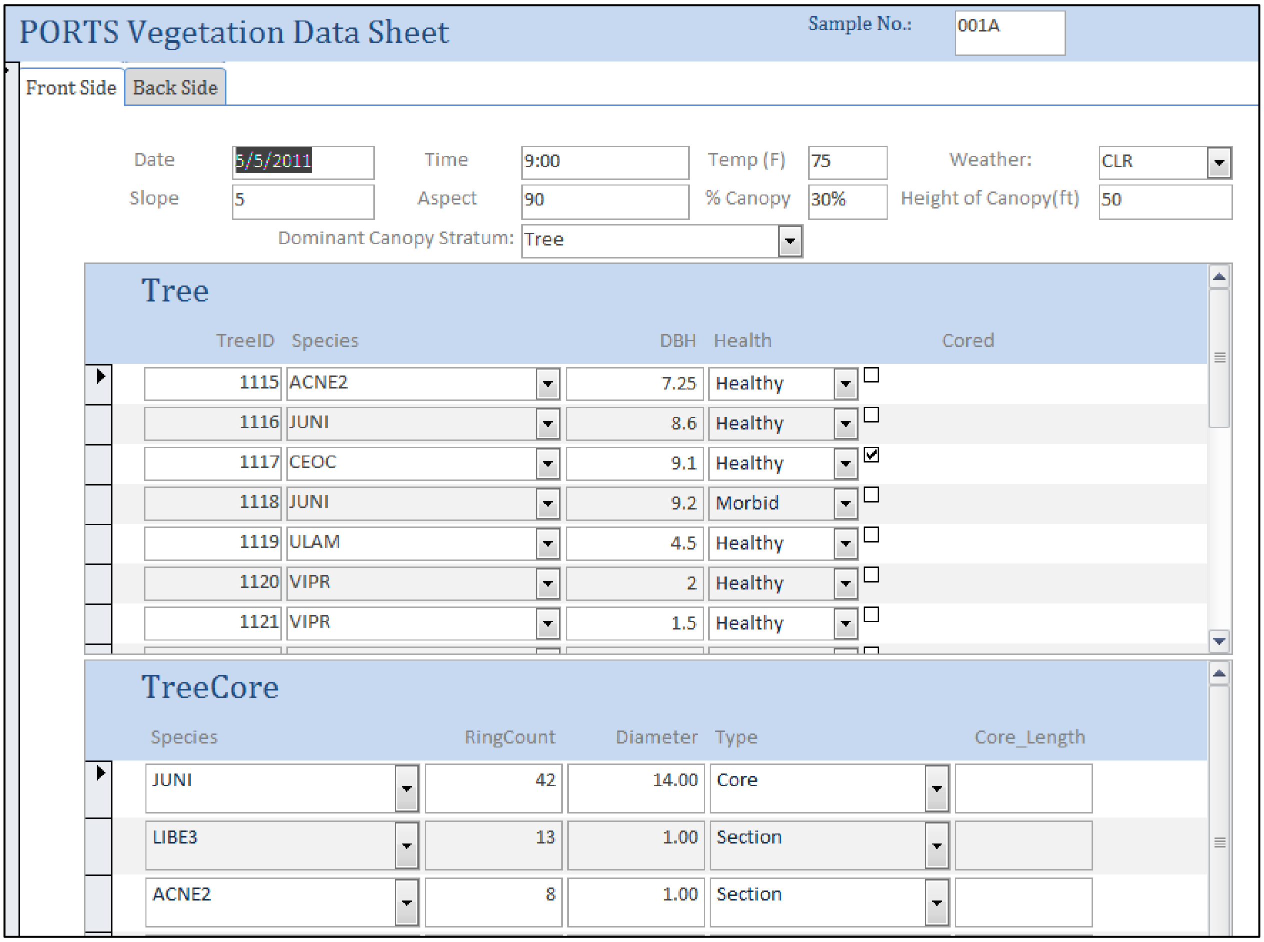

Figure 2.9 A portion of the digital data entry form in Microsoft Access

2.3.5 Quality Control Sampling

Field-truthing was used for quality control (QC) for approximately 20 percent of the mapped habitat polygons. The habitat/land use map was prepared in a continuous and iterative manner during field sampling. Once large portions of the map had been prepared in draft form, field maps were created to use for checking polygon accuracy. Field maps and special forms were prepared and bound. Once field-annotated, maps and forms were used by GIS specialists to confirm findings or make appropriate changes. Appendix F includes examples of forms used for field QC work.

2.3.6 Quality Control of Field Forms

Standardized field forms were developed for this project to facilitate the rapid and comprehensive collection of data in the field. The field forms were segregated into clearly labeled sections pertaining to the categories of data that were targeted by field researchers. The forms were printed on all-weather waterproof paper and written in #2 pencil to reduce the potential for loss of data or damage to the primary record. Field forms were collected at the end of each field session and returned to the office. The forms were then digitally scanned to capture the original field collected data before any QAQC or edits are performed. Each form was then reviewed by the lead field researcher for thoroughness and accuracy. Edits were made to the field forms using a black marker to distinguish edits from original field-collected data. The forms were then scanned again to maintain a comprehensive digital record of all data relevant to each sample plot.

A digital spreadsheet was created to track the creation, scanning, editing, and QAQC of each field form named “site log.” Columns were added during the 2012 field season to indicate which 2011 season sites had been revisited during the 2012 season. Separate field forms were created and tracked for sites that were revisited. Fields were also available in the spreadsheet to indicate the entry of data into the digital record and final QAQC of the digital database.

A separate spreadsheet was created to record data from the field-collected tree core and cross-section specimens. Once each specimen was mounted, labeled, and prepared for analysis it was entered into the spreadsheet. Attributes such as species, ring count, and estimated age for each specimen were then entered as linked to the primary field database.

2.4 Plant Species List Development

The major and most notable component of habitat in a biome with ample annual precipitation is vegetation. Vegetation is composed of individual specimens that are usually individuals at least above the ground surface. Individuals may cluster by species or multiple species may occur as cohorts in a recurring pattern that may be classified as a plant community, or an association. The dominant species (those occupying the larger portion of a community) are often the basis for naming of communities for floristic classifications (e.g., Oak-Hickory Forest). Such clusters groups and associations form by both competitions between individuals and as result of a similarity of physiological responses to site conditions. For example, a certain shared tolerance level of low oxygen soil conditions may favor a group of species that will cluster into a definable wetland plant community. Low soil fertility, doughtiness, shade tolerance, wind resistance, selective herbivory, susceptibility to fungal infestation and time since last disturbance are other examples of external forces that favor plants species and individuals to be repeatedly observed in certain sets of environmental conditions. Alternatively, the presence of such individuals and repeating species clusters reveals much about the physical conditions of a landscape, its recent influencing factors, its stability and its suitability for various management purposes. The identification and listing of species is thus the central component of a habitat classification and the basis for the use of various or habitat valuation models.

The species list for this project was developed both formally during quantitative collection in sample plots, and informally while moving between plots or during ground-truthing. All plant species encountered have been either identified in the field and recorded or collected for later taxonomic determination in the laboratory. Sample sheets were corrected to include species identified after sampling.

The species list was prepared in an Access database, where it can be linked with field sampling data and data analyses. The species list includes the scientific taxon, the author, the common name, the alphanumeric code used for sampling abbreviation; derived from the USDA PLANTS database (USDA NRCS 2011). The species list also includes additional taxonomic information, protection status (if any), weed status and a number of different valuation ratings.

Each species is rated by:

- Relative importance or Importance Value (IV) by habitat
- Regional wetland indicator status numerical equivalent (Reed *et al.* 1988)
- Native status ranking

- Coefficient of Conservatism (Andreas *et al.* 2004)
- Life form
- Habit

Ratings are used to express habitat quality through weighted frequency analysis as explained in Section 3 of this document. These can be adjusted for a target animal species, allowing comparative valuation between habitats. Relative ratings become the basis for predicting wildlife usage and population levels and are needed for wildlife habitat management. The fully annotated species list, along with the RI index, various measurements of site occupation (density, stems/unit area, basal area, percentage cover) and proximity/distance measurements derived in GIS can also be used to populate various Habitat Evaluation Procedure (HEP) and Habitat Suitability Indices (HSI) (see Section 4). The full species list included as part of the separate Access database contains 588 observed species. Many, particularly herbaceous species, were not observed in plots but in transit between plots. An abbreviated version of the plant species list is included as Appendix C.

2.5 Analytical Methods

Data collected at sample plots were analyzed to determine the characteristics of the PORTS plant community, relative to the successional time of community development since disturbance ended. At this stage, data was employed for the derivation of descriptive statistical characterization of the plant community. There are many inferential possibilities available in the dataset that may be applied later to support a species habitat model, an ecological risk assessment, a floristic quality index calculation, and a wetland frequency assessment. The data may also be used to populate models such as Twinspan and other detrended multivariate correspondence models. These data and calculation outcomes would be stored and used to display variable characteristics on a per habitat unit basis in the GIS and to direct management, maintenance and parcel disposal decisions. The methods used to calculate important plant community characteristics are described in this section. Findings and discussion of the findings are presented in Section 3. The characteristics of the plant community are described using the following community composition and structural parameters:

- Time since last drastic disturbance (farming, landfilling, materials discharge, grading, timbering, etc.) or "stand age"
- Life form dominance
- Dominance within each vegetative stratum
- Dominance by native plant species
- Wetland frequency
- Herbaceous ground cover density
- Site occupation as woody stem density
- Biomass as woody basal area
- Plant community diversity

2.5.1 Data Analysis Using SQL

Select Query Language (SQL) is a computer-interpreted syntax for writing queries to be processed against a relational database. The basic format is "*select*" a, b, c "*from*" table "*where*" condition. Figure 2.10 is an example of using spatial relationships to generate the number of vegetation plots per habitat type.

```
SELECT habitat, count(plotlocation.*)
FROM habitat
JOIN plotlocation
ON ST_Intersects(habitat.geometry,plotlocation.geometry)
GROUP BY habitat
```

Results in

Habitat	Count
Mixed Mesic Forest	5
Mature Oak Hickory	12
.	.
.	.

Figure 2.10 Example of a spatial SQL query

SQL was used to generate summary information for both quantitative and qualitative reporting. The use of SQL allowed data to be queried from related tables, which was often needed for aggregation and classification of habitat conditions.

2.5.2 Software Used

While there is never a one-size-fits-all software that can be utilized to accomplish all the necessary tasks in a project such as this, various software packages were used over the course of the project to optimize capability and performance. Each phase of the project contained a different set of objectives and thus required different software capabilities. A good example of such an issue is the difference between data entry and data analysis. While two preferred software packages might perform well with formatted data, one offers greater utility for data entry while the other provides improved data analysis capabilities. Therefore, the following programs were selected to accomplish the many objectives.

2.5.2.1 PostGIS

PostGIS is a platform developed for the PostgreSQL relational database management system (RDBMS) that enables spatial data types as well as a wide inventory of spatial functions to be used in developing queries. When dealing with large and diverse datasets with a spatial aspect, PostGIS currently affords the most capability. RDBMSs are often queried to answer questions regarding the sequence of data use. PostGIS allows queries to be written that include the "where" condition.

2.5.2.2 ArcGIS

Data were delivered using the Esri proprietary geodatabase format as required by the project‟s scope of work. What is referred to as a relationship class was used to link the tables based on their relationships. This allows a technician using ArcGIS software to identify plot location and view all the information attributed to that plot. Along with plot information, the digitized habitat cover dataset was contained in the geodatabase and delivered to DOE personnel in advance of this document. ArcGIS was also the software used to produce maps and figures presented throughout the course of the project.

2.5.2.3 Microsoft Access

Microsoft Access, a graphical user interface based RDBMS, was chosen for the ability to utilize forms for data population. Using its data entry form capabilities, Access allowed for simplified data entry procedures while still providing strict protocols for data quality.

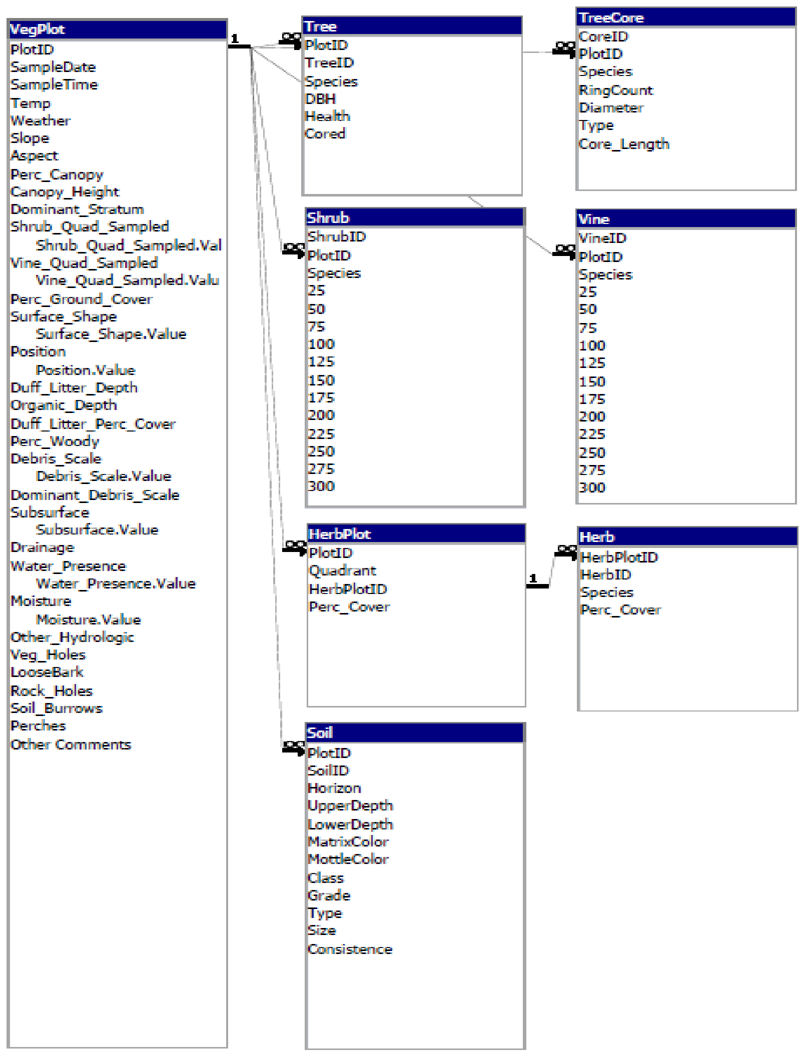

Figure 2.11 Diagram of table relationships

Each table in the database related back to the vegetation plots by utilizing one or more relationships. The table relationships are shown in Figure 2.11. A relationship between two tables depends on a common attribute. For example, the table of trees related to the vegetation plot based on the vegetation Plot ID. Each record in the trees table (see Figure 2.11) includes the ID of the vegetation plot it was sampled from so that one can use this relationship when needed for ecological analysis and calculation of values.

2.5.3 Woody Age

Using growth ring data from core and section samples collected at each plot, the minimum, maximum and average age of the woody vegetation was calculated per plot and within each mapped habitat type for trees and separately for shrubs and woody vines. Age of stand can, for example, be correlated with nativity, diversity and density indices to provide insights on time driven structural and composition relationships, which allow time-based predictions. Age data can be correlated with stem diameter data to prepare growth rate estimates and site indices. A site index translates all the factors that have affected tree growth at a site to a graphic predictive tool.

2.5.4 Importance Value

In order to assess species composition and dominance within each plot and habitat, and provide the magnitude for various qualitative assessments, an importance value (Curtis and McIntosh 1951; Bray and

Curtis 1957; Ayyad and Dix 1964) was calculated for each of the species present within the sample plot and compiled by habitat type. The importance value is the sum of two measurements, relative frequency (O) and relative dominance (S) for herbaceous species, and three measures for woody species, relative frequency (O), relative density (S), and relative dominance (B). The result is a numerical value that can range from zero to 200 that most thoroughly expresses the presence of a species in a community. Species having the highest importance values are the dominant members of the woody or herbaceous layer. Calculation of the importance value is the basis for development of the wetland prevalence and nativity indices, and for other species-based habitat valuation approaches. The importance value is determined by summary calculations of the *i^th^* species of the *j^th^* habitat and is defined as:

$$IV_{ij} = \frac{O_{ij}}{\sum_{i=1}^{n_j} O_{ij}} + \frac{S_{ij}}{\sum_{i=1}^{n_j} S_{ij}} + \frac{B_{ij}}{\sum_{i=1}^{n_j} B_{ij}}$$

where n is the number of species; O is frequency, or the number of times a species occurred in a sample plot; S is the density, or the number of stems recorded; and B is dominance, or the total herbaceous cover or total woody basal area. The importance value is most often represented as a sum of percentages, a convention followed in this report.

2.5.4.1 Importance Value Weighted Averages

There are several ordinal indexes in which each species is assigned a value. These include for example, C of C, WPI, and Nativity. To calculate index values weighted by the importance value of species, the following equation is used:

$$A_j = \frac{\sum_{i=1}^{n_j} I_i * IV_{ij}}{\sum_{i=1}^{nj} IV_{ij}}$$

where A_j weighted average of I for the j^{th} habitat, n_j is the number of species in the j^{th} habitat, I_i is the index value of the i^{th} species, and IV_{ij} is the importance value for the ith species of j^{th} habitat.

The result of these calculations is based on the definable unit of habitat. These values can be calculated on a plot per plot basis, or on a larger scale grouping or classification.

2.5.4.2 Individual Species Count

The individual species count is the number of individuals of a woody species recorded in a sample plot or the number of sub-plots within a sample plot at which an herbaceous species is found. Individual species count is used to determine the total frequency and dominance of a species.

2.5.4.3 Total Frequency

Total frequency expresses the species presence concept. Frequency is the number of times a species occurs in a number of sample plots or subplots in a total sample site. Total frequency for a woody species in the sample plot is the number of woody individuals of that species counted in the plot. For the herbaceous species, total frequency is the number of plots in which the species occurs. Total frequency is used to determine the relative frequency of a species within a sample point, a community, a sub-basin or the entire creation site (Daubenmire 1959, Bonham 1989).

$$S_{ij} = \sum_{i=1}^{n_{ij}} 1$$

where n_{ij} is the number of individuals of the j^{th} habitat of the i^{th} species.

2.5.3.4 Relative Frequency

Relative frequency is the total frequency value converted to a percentage. The total frequency for each woody species is divided by the total number of woody stems counted of all species to yield the relative frequency. For the herbaceous stratum, relative frequency is calculated by dividing the number of subplots at which a species occurred by the total number of subplots. Relative frequency is used to determine the importance value of a species within a plot, a subplot or the entire sample area set.

2.5.4.5 Total Woody Dominance

Woody dominance is assessed by comparison of woody basal areas. Basal area is a per unit area biomass measurement. Basal area is the cross-sectional area in square feet of wood at the diameter measurement location (dbh for trees, base for shrubs). Woody dominance is the sum of basal area per species per habitat. In the field, the diameter of woody vegetation was measured in inches.

The equation to calculate basal area is:

$$B_{ij} = \sum_{i=1}^{n_{ij}} \frac{D^2 * \pi}{4 * 144}$$

where n_{ij} is the number of individuals of the j^{th} habitat of the i^{th} species, D is the diameter. The conversion factor of 1/144 was used to produce a result in square feet instead of square inches. Total basal area for a species is sum of the calculated basal area for all diameter classes for which the species was recorded.

2.5.4.6 Relative Woody Dominance

Relative woody dominance is the percentage calculated by dividing the total woody dominance for each species by the total woody basal area for the plot.

2.5.4.7 Total Herbaceous Dominance

Herbaceous plant dominance, or density, is measured by cover percentage. The total dominance is the average of the percent cover per sample subplot for an individual species. For example, a species found in two sample subplots with areal coverage of 40 and 50 percent, respectively, has a total dominance of 45 percent.

2.5.4.8 Relative Herbaceous Dominance

The total dominance value converted to a percentage. This indicates the portion of the sampled plant community a species represents within a subplot or the entire sample area set.

2.5.5 Wetland Prevalence Index

In order to assess changes in the herb and shrub layer due to changes in hydroperiod, the wetland frequency index (prevalence index after Environmental Laboratory 1987) was calculated. The wetland frequency index is a weighted frequency analysis used to assess the importance of hydrophytic species (defined based on frequency of occurrence within wetlands) within a plant community. The prevalence index ranges from 1 (wetlands) to 5 (uplands). Significant changes in the local hydroperiod should be reflected in significant shifts in the composition of the plant community, because the importance of hydrophytic species is linked to the plant community hydroperiod. This shift in plant community composition would be reflected in an increase or decrease in the wetland prevalence index as the importance of hydrophytic species increases or decreases due to the change in hydroperiod. A significantly increased hydroperiod would result in a lower wetland prevalence index (Malecki *et al.* 1983; Enviromental Laboratory 1987). A significantly decreased hydroperiod would result in a higher wetland prevalence index (Schneider and Ehrenfeld 1987; Environmental Laboratory 1987).

Wetland indicator status, which is an estimation of a species frequency of occurrence in wetlands, is assigned using Reed (1998). The assigned values, which are used in the calculation of the prevalence index, for each wetland indicator status are presented in Table 2.4. Based on this assignment of ordinal values, wetland prevalence index values of 3.0 or less indicates dominance by hydrophytes; the site is a wetland. Values of greater than 3.0 indicate dominance by non-hydrophytes; the site is not a wetland.

The wetland prevalence index is calculated using the weighted averaging method as applied by Jongman *et al.* 1995. This method is the same method used by Environmental Laboratory (1987) to determine this index. The wetland frequency index is calculated using the general formula:

$$WPI_j = \frac{\sum_{i=1}^{n_j} f_i * IV_{ij}}{\sum_{i=1}^{n_j} IV_{ij}}$$

where, WPI_j is the wetland prevalence index of the j^{th} habitat, f_i is the wetland indicator status of the i^{th} species, and IV_{ij} is the importance value of the i^{th} species of the j^{th} habitat (Jongman *et al.* 1995).

Table 2.4 Wetland Indicator Status Categories

Wetland Indicator Status	Description	Frequency Scale Value
OBL	Plants that occur usually (estimated probability > 99%) in wetlands under natural conditions.	1.0
FACW+	More frequently found in wetlands than that reported for FACW status.	1.5
FACW	Plants that usually occur in wetlands (estimated probability 67-99%), but occasionally found in non-wetlands.	2.0
FACW-	Less frequently found in wetlands than that reported for FACW status.	2.33
FAC+	More frequently found in wetlands than that reported for FAC status.	2.66
FAC	Plants that are equally likely to occur in wetlands or non-wetlands (estimated probability 34-66%).	3.0
FAC-	Less frequently found in wetlands than that reported for FAC status.	3.33
FACU+	More frequently found in wetlands than that reported for FACU status.	3.66
FACU	Plants that occur sometimes (estimated probability 1% to 33%) in wetlands, but occur more often in non-wetlands.	4.0
FACU-	Less frequently found in wetlands than that reported for FACU status.	4.5
UPL	Plants that occur rarely (estimated probability <1%) in wetlands, but occur usually in non-wetlands under natural conditions.	5.0

2.5.6 Nativity, Native Status Index

This parameter considers the origin of the species and the growth habits of the species. A high nativity index indicates a predominance of alien species or invasive native species, collectively referred to as weeds. Alien species are plants, which are not indigenous to the central Mississippi River region and/or North America. Alien species may be invasive or non-invasive. A prevalence of alien weeds suggests low quality habitat. Native species are species considered indigenous to Ohio. Invasive native species are indigenous plants that rapidly colonize or invade disturbed sites, often becoming dominants to the point of creating a monoculture. A prevalence of invasive weeds often results in habitats with low diversity and low quality as wildlife habitat. A scale ranging from 5 (most native/desirable) down to 1 (non-native, invasive/less desirable) was used to rank each sample point by nativity (see Table 2.5). The selection of a nativity rating for each species relied significantly on Braun (1961), Fischer (1988), Cooperrider (1995), Braun (1967) and the UDSA NRCS PLANTS database (http://plants.usda.gov/java/).

The nativity index for each plot and habitat is determined by the weighted averaging method identical to that used to develop the wetland prevalence index. A higher nativity index indicates a site that is occupied by invasive alien weeds, indicating lower quality habitat.

Table 2.5 Native Status Scale

NATIVE STATUS SCALE	STATUS	DESCRIPTION
5	Noninvasive Native	A species indigenous to southern Ohio that is noninvasive and non-weedy.
4	Invasive Native	A species indigenous to Ohio that is invasive and/or weedy. These species are often found along roadsides or in heavily disturbed waste places or eutrophic wetlands.
3	Planted or Naturalized Hybrid	Species used for reclamation, soil stabilization, green manure, organic material build-up, which may be naturalized by, but would not persist in a dominant position without maintenance.
2	Noninvasive Alien	A species not indigenous to Ohio that is non-invasive and non-weedy.
1	Invasive Alien (noxious weed)	A species not indigenous to Ohio that is invasive and/or weedy. These species are often found along roadsides or in heavily disturbed waste places. This may include planted hybrids that not only persist without maintenance, but also out-compete native species.

2.5.7 *Floristic Qualitative Assessment Index and the Coefficient of Conservatism.*

The Ohio Floristic Qualitative Assessment Index (FQAI) is a simple ordination method based on weighted averaging (Gauch 1982). It is calculated using species abundance and a weighting factor based on a species conservation value to derive a plant community rating that can be used to compare the relative state of ecosystem integrity between communities. Ecosystem integrity has been defined as “the capability of supporting and maintaining a balanced integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region” (Karr and Dudley 1981).

The selected weighting factor, identified as the Coefficient of Conservatism (C of C), is an ordinal number assigned to a plant species based on its ecological tolerances and its intolerance to external disturbances to a presumed “natural” condition. The C of C represents the degree of conservatism (fidelity to undisturbed conditions) that a species demonstrates by its occurrence within a particular habitat. A species is rated on a scale of 0 to 10 as presented in Table 2.6.

Table 2.6 Summary of coefficients of conservatism used in the FQAI for vascular plants (Andreas *et al.* 2004)

C of C	Description
0	Plants with a wide range of ecological tolerances. Often these are opportunistic invaders of natural areas (e.g. *Lonicera japonica, Ailanthus altissima)* or native taxa that are typically part of a ruderal community (e.g. *Polygonum pensylvanicum, Ambrosia artemisiifolia*)
1 to 2	Widespread taxa that are not typical of (or only marginally typical of) a particular community such as *Solidago canadensis* or *Impatiens capensis*
3 to 5	Plants with an intermediate range of ecological tolerances that typify a stable phase of some native community, but persist under some disturbance (*Asclepias incarnata, Ulmus rubra, Galium triflorum)*
6 to 8	Plants with a narrow range of ecological tolerances that typify a stable or near "climax" community (e.g. *Goodyera pubescens, Cardamine angustata, Eupatorium album*)
9 to 10	Plants with a narrow range of ecological tolerances that exhibit relatively high degrees of fidelity to a narrow range of habitat requirements (e.g. *Epifagus virginiana, Solidago uliginosa)*

The FQAI for the j^{th} habitat is defined as:

$$FQAI_j = \frac{\sum_{i=1}^{n_j} C\ of\ C_i}{\sqrt{n_j}}$$

where C of C_i is the coefficient of conservatism for a species and *i* is the number of species. This calculation is performed for all species as well as only for native species. The native-only calculation is the original FQAI calculation and one most often reported. This assessment prefers use of all species because the high importance of non-native species in most habitats truly reduces the floristic quality in spite of the occurrence of a relatively few highly rated individuals.

2.5.8 Species Diversity

Species and habitat diversity metrics approximate the number of species present in a fixed geographic area, with consideration for their abundance and distribution. Calculated diversity metrics often serve as expressions of ecosystem health and vigor, with greater diversity often considered to suggest increasing ecosystem health (although this notion is misleading in highly stressed conditions such as saline environments, alpine regions and deserts). Species diversity is a function of species richness (the number of species present in an area) and evenness (the relative distribution of individual species within a sampled area). Three diversity measurements are used: simple species count per unit area (plot, habitat, site), Simpson's Heterogeneity and Shannon‟s Diversity Index. The simple species count is the number of species found in a defined area, and can be recalculated as area (plots, habitat acreage) increase. It is suggestive of the diversity of a fixed area, but does not fully address plant community structural characteristics such as frequency, distribution, arrangement and dominance. Since there is no measurement of diversity that fully describes complex reality, two additional statistical methods are used and described as follows.

2.5.8.1 Simpson's Heterogeneity

Simpson‟s diversity index (Simpson 1949) was proposed as a method for simultaneously measuring both components of species diversity. Because Simpson‟s diversity index simultaneously measures two components of diversity, it may be represented in several ways. Used here, Simpson‟s diversity index represents the probability of interspecific encounter, $\in_1$ (i.e., the probability of randomly picking two individual organisms belonging to different taxa in a given area) (Hurlbert 1971). The formula used to calculate $\in_1$ is as follows:

$$\in_1 = \left\{\frac{N}{N-1}\right\}\left\{1 - \sum\left(\frac{n_s}{N}\right)^2\right\}$$

where $\in_1$ is the probability of interspecific encounter, n_s is the importance value of species s in a quadrant and N is the sum of all importance values in a quadrant; i.e., $\Sigma\, n_s$. Simpson‟s index ranges from 0.0 (low probability of interspecific encounter) to 1.0 (high probability of interspecific encounter). Species diversity may be calculated separately for each vegetative layer, for a plot, for a habitat type or for an entire site under assessment.

2.5.8.2 Shannon's Diversity Index

The Shannon diversity index, or Shannon's diversity index, the Shannon-Wiener index, the Shannon-Weaver index and the Shannon entropy (Shannon 1948) were originally proposed to quantify uncertainty or information content in arrays of different objects (such as species). The more different kinds of objects (species of different taxa) and the closer to equality is their proportional abundances, the more difficult it is to predict which species will be the next one found in a random observation. A high Shannon diversity value for the population of an ecosystem indicates the presence of many species, none of them dominant. A low value would be derived for a population strongly dominated by one or two species. The Shannon index quantifies the uncertainty (entropy or degree of surprise) associated with its prediction. A finding of a high Shannon index generally correlates with a high level of niche variability within a defined habitat type. A low index not only correlates with a uniformity of ecological conditions, it also may indicate the presence of a stressor, such as a chemical imbalance or an unusually high organic concentration in environmental media.

Shannon‟s diversity index (H‟) is calculated as follows:

$$H' = -\sum_{i=1}^{R} p_i \log p_i$$

where p_i is the proportion of individuals belonging to the i^{th} species in the dataset of interest, R is the number of species. Then the Shannon entropy quantifies the uncertainty in predicting the species that is taken at random from the dataset. The base of the logarithm used when calculating the Shannon entropy can be chosen freely. Shannon himself discussed logarithm bases 2, 10 and e, and these have since become the most popular bases in applications that use the Shannon entropy.

2.5.9 Herbaceous Ground Cover Density

Ground cover density per plot, expressed as percent obscurance of the soil surface, is derived by summing the estimated percentage areal coverages for all species recorded in each plot.

2.5.10 Woody Stem Density

Woody stem density is calculated for each plot on an acreage (or other per unit area basis) density basis (woody stems per acre) by counting the total number of stems of all species per plot and multiplying by the number of possible plots per acre. Since each 10-meter radius plot is approximately 3380 square feet, the number of possible plots per acre is 12.9. Each count woody stem thus equals 12.9 stems of that diameter class per acre.

2.5.11 Average Woody Diameter

Woody species are tallied in each plot by the measured diameter classes. The dominant diameter class was derived using the weighted averaging approach applied separately for trees and shrubs.

2.5.12 Dominant Life Form

In order to differentiate between a forested and a shrub-scrub structural community at the successional growth stage of each tract, species based dominance per life form was calculated. Most tracts were found to contain both tree species and shrub species. The relative importance of either life form determines whether the tract is classified as forest or shrub community. A weighted frequency analysis employed the average diameter for the total woody stems per tract multiplied by a weighting factor. For a tree, the weighting factor was 1.0 for shrub, 2.0. Table 2.7 summarizes the dominant life form assessment.

Table 2.7 Life Form Index

Life Form Index	Dominant Life Form
>1.75-2.0	Tree
>1.5-1.75	Small Tree
1.25-1.5	Tall Shrub/sapling
0.5-1.4	Low Shrub
<0.5	Grass/ Herb

As a modifier, the height of the normal growth habit for the dominant species was considered. The overlap of the tall and low shrub categories is to identify the range (1.25 to 1.4) at which the life form decision would be made based on species growth characteristics. Calculated indices less than 0.5 support small diameter shrubs in low densities or no shrubs and are presumed to be grass and herb dominated communities.

2.5.13 Woody Vegetation Health

During sampling, trees and saplings are noted as healthy, morbid (dying) or dead. A morbidity-mortality index may be developed on a plot or habitat basis as a ratio of morbid or dead stems to live stems (total) or to develop a similar ratio for any species on a habitat or site-wide basis. These factors can be used to assess wildlife habitat value (denning, nesting), serve to point out and map relative areas of morbidity and mortality.

2.5.14 Reproduction

Canopy tree species counted in the shrub and herb layers and considered as reproduction during sampling represent the potential next generation of canopy species. The count or density of canopy species stems in the understory suggest whether a forest is stable (and reaching successional climax), the understory is composed of canopy species, or in transition, the understory seedlings composition is not dominated by canopy species. Reproduction of woody vegetation can provide insights on stand productivity as the number of seedlings per unit area.

3.0 DISCUSSION OF FINDINGS

This section presents the first tier statistical findings using the plot data and the analyses discussed in Section 2.0 to describe characteristics of the thirteen vegetated habitats delineated for the study area. This analysis represents some of the findings of sampling and analysis; primarily elements of site occupation (species dominance and biomass) and habitat valuation. These characteristics are observations of the current habitat conditions during the time of the study. While the growth rate of woody vegetation is evaluated here, some trends that could emerge from the collected data include reproductive fidelity, mortality, the gradual dominance of invasive species and timber valuation but are not fully addressed here. Wildlife habitat values are separately assessed in Section 4.0 of this document and mapped wildlife signs are presented in Appendix D.

Table 3.1 summarizes a range of descriptive characteristics and valuations that provide insights to understanding and discussing the biota of the study area. Vegetation and habitat data collected at 150 sample plots were segregated using the GIS habitat map polygons as selectors and analyzed to characterize the plant communities in the study area. Sample plots were field-selected based on the ability of sampling team ecologists to discern differences in general species composition, tree trunk size, canopy height and changes in physical features of slope, aspect and drainage. As a result, samples were collected inside of habitat types, with edges (ecotones) rarely represented in sampling data. This is an important known omission from the field plots because the majority of invasive species can be casually observed in the transition areas between open grassy areas and forests and are thus under-represented in our sampling.

Table 3.1 is divided by habitat types (columns), characteristics and each measurement are listed in the 22 rows. The significance of each row is explained in this section.

Table 3.1 Characteristics and Valuations of Vegetated Habitats within the PORTS Study Area

	Habitat Code:	3	4	5	6	7	8	9	10	11	12	15	16	18
Data Row	**Habitat***	**Mature Oak-Hickory Forest**	**Mixed Mesic Forest**	**BLHF**	**Native Pine**	**PFO Wetland**	**PSS Wetland**	**PEM Wetland**	**Successional Forest**	**Successional Scrub**	**Oldfield - Successional**	**Ruderal Successional**	**Planted Pine**	**Mowed Grass/Lawn**
	Characteristic or Value													
1	**Dominant Canopy Stratum Life Form**	Tree	Tree	Tree	Tree	Tree	Shrub	Herb	Tree/Sap	Shrub/Sap	Herb	Shrub/Sap	Tree	Grass
2	**Dominant Tree Species Codes****	QUAL, ACSA3, CAOV2, QUVE	ACSA3, LITU, PRSE2, CAOV2	ACSA3, PLOC, ASTR, JUNI	PIVI2, ACSA3, PIST, SAAL5	PLOC, ACRU, JUNI, ACSA2	QUIM, ULAM, COFL2, JUNI	SAIN3, FRPE, PODE3, DIVI5	ACSA3, PIVI2, ACRU, SAAL5	PIVI2, RHCO, JUVI, DIVI5	ACRU, PIVI2, QUIM, DIVI5	SAIN3, PLOC, PIVI2, SASE	PIRE, PIST, FRPE, GLTR	NA
3	**Mean Age (as ring count of dominant trees)**	85.5	56.51	68.58	45.71	39.73	10.5	NA	47.88	NA	NA	16	21.25	NA
4	**Canopy Height (feet)**	59.14	55.32	66.88	50.71	50.00	20.00	20.75	50.71	17.50	2.50	6.67	27.50	NA
5	**Tree Diameter-at-Breast-Height or DBH (inches)**	14.26	13.50	14.90	12.19	13.23	11.14	11.63	12.43	NA	NA	10.15	9.40	NA
6	**Tree Basal Area/acre**	156.0	167.5	159.5	155.2	132.9	34.6	14.4	145.3	6.9	3.3	8.8	122.4	NA
7	**Tree Count (stems/acre)**	364.4	364.2	368.9	469.5	439.2	203.0	337.7	486.1	135.3	116.0	189.0	431.8	
8	**Growth Rate Trees (in/yr mean diameter increase)**	0.12	0.17	0.15	0.17	0.20	0.15	0.25	0.15	0.13	0.13	0.13	0.27	NA
9	**Dominant Shrubs/Saplings**	QUAL, SMRO, RUAL, ASTR	ROMU, ASTR, SAAL5, LIBE3	ROMU, LIBE3, ASTR, HYPR	VAPA4, SMRO, SAAL5, ACSA3	ROMU, FRPE, ACRU, LOMA6	HYPR, SASE, SAIN3, RUAL	SAIN3, ROMU, FRPE, ACRU	ROMU, HYPR, ASTR, RUAL	NA	HYPR, ACRU, ROMU, RHCO	GLTR, HYPR, SAIN3, VIDE	ELAN, FRPE, COFL2, LOMA6	DIVI5, RUAL, COFL2, ROMU
10	**Dominant Vines**	TORA2, LOJA, VIAE, PAQU2	VIAE, PAQU2, LOJA, TORA2	VIRI, PAQU2, TORA2, LOJA	VIVU, LOJA, PAQU2	LOJA, VIRI, TORA2, PAQU2	NA	TORA2, LOJA, PAQU2, VIRI	NA	LOJA, SMGL	NA	NA	VIAE, TORA2, PAQU2	NA
11	**Woody Basal Area (sq. ft./acre)**	157.2	168.8	162.5	156.1	136.9	40.8	15.6	148.0	8.7	5.5	11.5	123.7	NA
12	**Total Stems/acre**	1460.3	1564.1	2588.1	1634.9	2962.3	3434.7	886.7	2323.5	1301.7	1625.5	1890.3	1050.4	NA
13	**Growth Rate Subcanopy (in/yr mean diam. Increase)**	0.04	0.05	0.05	0.05	0.06	0.12	0.08	0.09	NA	0.05	0.07	0.10	NA
14	**Dominant Herbs**	ACRU, SAAL5, PAQU2, SMRO, VAPA4,	AGAL5, LOJA, PAQU2, PRSE2, LEVI2,	AGAL5, PAAU3, VEAL, TORA2, IMCA,	ACRU, SAAL5, TORA2, SMRO, PAQU2,	VEAL, AGAL5, LOJA, ROMU, TORA2,	NA	LEOR, JUEF, SYLA4, SCCY, PONA4,	LOJA, TORA2, AGAL5, PAQU2, POAC4,	NA	ANVI2, POPR, LECU, HYPR, SOCA6,	LECU, SOCA6, POPR, ONSE, TORA2,	SANI4, LOJA, PAQU2, PHAM4, TORA2,	RUFL, VEGI, ALPR3, DECA7, TORA2,
15	**Average % Ground cover**	26%	39%	64%	36%	76%	98%	89%	50%	100%	96%	98%	43%	NA
16	**Number of species**	138	215	169	64	144	97	63	95	27	129	39	29	43
17	**Shannon's Diversity**	2.160	2.125	2.453	2.208	2.492	2.642	1.942	2.621	1.782	2.029	2.365	1.977	1.616
18	**Simpson's Heterogeneity**	0.865	0.836	0.886	0.827	0.891	0.918	0.731	0.908	0.674	0.749	0.900	0.829	0.478
19	**Wetland Index (1-5)**	4.22	3.82	3.44	4.15	3.16	3.07	2.37	3.78	4.19	3.76	3.21	3.56	3.53
20	**Nativity Index (1-5)**	4.88	4.47	4.42	4.93	4.19	4.60	4.56	4.40	4.82	4.41	4.31	3.84	4.14
21	**C of C Index (1-10)**	4.64	3.50	3.55	4.12	3.06	2.61	2.26	3.11	3.19	2.61	2.82	2.12	2.29
22	**FQAI (dimensionless)**	14.45	12.14	15.61	14.94	14.11	12.76	10.14	13.77	11.97	12.56	8.83	7.68	10.56

* Refer to Appendix A for habitat classification and map
** Refer to Appendix C for species codes

3.1 Plant Species Statistics

There were 588 vascular plant species recorded with the PORTS study area. The full listing is found in Appendix C and contained in the project Access database. Species were rated by several characteristics as discussed in Section 2.0. There were 440 species (75%) recorded in sample plots. The remainder species were found in small niche habitats, below minimum mapping scale, observed during travel between sample points. These ratings allow multiple statistical summaries that provide different perspectives into the structure and composition of the vegetated habitats in the study area. Statistics are presented in a series of tables that follow. Table 3.2 presents species native status statistics and Table 3.3 presents wetland status count by species. Table 3.4 presents the count of Coefficient of Conservatism ratings across the study area, while Table 3.5 presents the species count by growth form.

There were 108 plant families represented in the species list. Table 3.6 lists the twelve plant families represented by two percent or greater of the plant species composition. The remaining 96 families comprise 45 percent of the species present.

Table 3.2 Species Native Status Summary

Nativity Status	Count	Percent
Noninvasive Native	474	81%
Invasive Native	33	6%
Planted or Naturalized Hybrid	9	2%
Noninvasive Alien	7	1%
Invasive Alien	65	11%
Grand Total	**588**	

Table 3.3 Wetland Status Count by Species

Wetland Indicator Status	Scale	Count	Percent
Wetland Obligate	1	59	10%
Facultative Wetland +	1.5	25	4%
Facultative Wetland	2	57	10%
Facultative Wetland -	2.33	15	3%
Facultative +	2.66	7	1%
Facultative	3	72	12%
Facultative -	3.33	14	2%
Facultative Upland +	3.66	7	1%
Facultative Upland	4	111	19%
Facultative Upland -	4.5	57	10%
Upland Obligate	5	164	28%
Percent Facultative and Wetter			40%
	Grand Total	**588**	

Table 3.4 Coefficient of Conservatism (C of C) Rating Count

Rating	Description	Count	Percent
0	Plants with a wide range of ecological tolerances. Often these are opportunistic invaders of natural areas or native taxa that are typically part of a ruderal community.	98	17%
1 to 2	Widespread taxa that are not typical of (or only marginally typical of) a particular community.	96	16%
3 to 5	Plants with an intermediate range of ecological tolerances that typify a stable phase of some native community but persist under some disturbance.	259	44%
6 to 8	Plants with a narrow range of ecological tolerances that typify a stable or near "climax" community.	127	22%
9 to 10	Plants with a narrow range of ecological tolerances that exhibit relatively high degrees of fidelity to a narrow range of habitat requirements.	8	1%

Table 3.5 Species Count by Growth Form

Growth Form	Count	Percent
fern	21	4%
forb	345	59%
grass	49	8%
sedge	42	7%
shrub	44	7%
small tree	13	2%
tree	54	9%
vine	20	3%
Grand Total	**588**	

Table 3.6 Count of Dominant Plant Families (those =/> 2% of total species count)

Dominant Families	Common Name	Count	Percent
Asteraceae	Sunflowers	79	13%
Poaceae	Grasses	49	8%
Cyperaceae	Sedges	42	7%
Rosaceae	Roses	30	5%
Fabaceae	Beans-Legumes	27	5%
Lamiaceae	Mints	23	4%
Liliaceae	Lilies	18	3%
Fagaceae	Oaks	13	2%
Polygonaceae	Buckwheats	13	2%
Rubiaceae	Madders	13	2%
Scrophulariaceae	Snapdragons	10	2%
Brassicaceae	Mustards	9	2%
Number of Species in Dominant Families		**326**	**55%**

Table 3.7 Species with a Special Status list by the State of Ohio

Taxon	Common Name	Ohio State Special Status (2012-13)	On-Site PORTS
Acorus americanus	American Sweetflag	Potentially Threatened	YES
Ailanthus altissima	Tree-of-Heaven	Invasive	YES
Alliaria petiolata	Garlic Mustard	Invasive	YES
Berberis thunbergii	Japenese Barberry	Invasive	YES
Botrychium biternatum	Sparselobe grapefern	Endangered	YES
Bromus inermis	Smooth Brome	Invasive	YES
Calamagrostis porteri	Porter's Reedgrass	Threatened	YES
Celastrus orbiculatus	Oriental bittersweet	Invasive	YES
Conium maculatum	Poison Hemlock	Invasive	NO
Daucus carota	Quenn Anne's Lace	Invasive	YES
Dipsacus fullonum	Teasel	Invasive	YES
Elaeagnus angustifolia	Russian Olive	Invasive	YES
Euonymus alatus	Burningbush	Invasive	YES
Eupatorium album	White Thoroughwort	Threatened	YES
Galium palustre	Common Marsh Bedstraw	Endangered	YES
Hesperis matronalis	Dames Rocket	Invasive	YES
Juncus secundus	Lopsided Rush	Potentially Threatened	NO
Krigia dandelion	Potato Dwarfdandelion	Threatened	YES
Ligustrum vulgare	European privet	Invasive	YES
Lonicera japonica	Japenese Honeysuckle	Invasive	YES
Lonicera maackii	Bush/Amur Honeysuckle	Invasive	YES
Luzula bulbosa	Bulbous Woodrush	Threatened	YES
Lysimachia nummularia	Moneywort	Invasive	YES
Melilotus officinalis	Yellow Sweetclover	Invasive	YES
Microstegium vimineum	Asian Microstegium	Invasive	YES
Ornithogalum umbellatum	Star of Bethlehem	Invasive	NO
Packera paupercula	Balsam Groudsel	Threatened	NO
Piptochaetium avenaceum	Blackseed Speargrass	Endangered	NO
Polygala incarnata	Procession Flower	Endangered	YES
Potamogeton natans	Common Pondweed	Potentially Threatened	YES
Quercus marilandica	Blackjack Oak	Potentially Threatened	YES
Rosa blanda	Smooth Rose	Potentially Threatened	YES
Rosa multiflora	Multifloral Rose	Invasive	YES
Salix caroliniana	Coastal Plain Willow	Potentially Threatened	YES
Securigera varia	Crown Vetch	Invasive	YES
Solidago odora	Anisescented Goldenrod	Threatened	YES
Sorghum halepense	Johnsongrass	Invasive	YES
Typha angustifolia	Narrowleaf Cattail	Invasive	YES

Table 3.7 lists the 38 plants species found within the study area that have a special listing with the state of Ohio (as of September 15, 2012) for either their rarity or their invasive status. An exhaustive search for species was not performed, nor was the multi-level criteria required to declare the presence of listed species on-site achieved. The intent of this project was to characterize habitats in order to determine areas where more intensive searches for listed species should be performed based on project requirements. Field identification of plant species was the principal methodology employed. However, some plant vouchers were identified in the lab, mostly for specimens that were either of poor quality or very difficult to identify to species.

Table 3.8 is a list of the most dominant species found within the study area. This listing is based on Importance Values (IV) as calculated from sample plot data. IV combines frequency of occurrence in habitats and the relative biomass of the species. Shaded rows identify invasive and noxious species demonstrating their very strong presence in the study area. This contrast with Table 3.2 which lists native species as comprising 88% of the number of species found. The species that occupy the most of the ground surface in most parts of the study area are invasive or alien species.

Table 3.8 Plant Species with Combined Importance Values of Greater than 90 and Total Species per Vegetated Habitat Type

Vegetated Habitat Type	BLHF	Mature Oak-Hickory Forest	Mixed Mesic Forest	Mowed Maintained	Native Pine	Oldfield - Successional	Palustrine Emergent Wetland	Palustrine Forested Wetland	Palustrine Shrub-Scrub Wetland	Planted Pine	Ruderal Successional	Successional Forest	Successional Scrub	Habitat Occurrence
Taxon	**Importance Value by Habitat Occurrence**													
Rosa multiflora	36.4	3.4	25.0	15.8	3.5	17.7	28.1	42.9	11.0	5.6	9.8	21.9	5.7	13
Lonicera japonica	5.2	2.1	5.0	52.1	1.5	4.3	6.0	15.8	14.8	16.1	5.3	12.3	12.0	13
Pinus virginiana		2.1	1.9		58.1	37.1			3.7		24.8	14.1	64.0	8
Hypericum	3.9	2.5	4.9		3.3	61.9	5.5	0.7	22.1	5.6	18.2	10.7	38.6	12
Acer rubrum	6.3	5.1	4.9		10.5	63.3	9.7	12.4	15.7	5.5	9.9	9.5	9.8	12
Diospyros virginiana		1.1	1.9	127.3	1.1	8.2	16.4			7.4	6.5	2.1	14.7	10
Rubus allegheniensis	3.8	11.6	6.7	52.1	7.8	11.2	7.4	2.3	14.8	6.8		9.8	23.4	12
Acer saccharum	30.1	19.6	47.2		10.7			3.8	1.6			39.4		7
Fraxinus	11.3	5.4	8.6		14.0	5.7	31.0	13.1	2.2	12.2	5.6	9.8	8.9	12
Salix interior						2.2	86.9	0.7	9.3		24.9			5
Platanus	18.7	0.3	5.0				9.6	32.8	19.2		36.5	5.6		8
Toxicodendron	5.2	1.6	2.5		5.3	2.5	6.1	8.7	5.1			4.6		9
Cornus florida	5.3	5.4	5.5	21.1	6.1	6.7	4.8	3.2	6.3	8.1	10.9	3.3	8.4	13
Prunus serotina	8.8	3.1	12.0		1.0		4.5	1.9	11.8	5.6	6.6	11.6	7.4	11
Sassafras albidum	1.4	9.2	12.0		15.3		14.9	0.8	4.4			7.9		8
Parthenocissus	5.4	0.8	4.5		1.0		4.6	7.3	3.2	12.4		6.3		9
Quercus alba	1.9	48.3	7.6		10.8	3.4						2.2	4.7	7
Pinus resinosa										84.0				1
Gleditsia triacanthos			2.2			8.8		1.4	5.9	7.2	50.4	4.6		7
Smilax rotundifolia	5.8	13.4	6.3		14.5		4.2		3.5	5.0		3.4		8
Pinus strobus					12.2					60.1				2
Andropogon														0
Quercus imbricaria	1.9	0.9	3.7		3.3	6.1		1.9	19.3		14.3	3.0	4.7	10
Juglans nigra	11.8	0.5	6.0			6.3		17.5	13.0			3.0		7
Lindera benzoin	17.6		5.3		3.4			6.9	2.7	5.6		5.5		7
Asimina triloba	17.0	7.1	14.9		1.3			5.1				8.4		6
Rubus flagellaris		1.1	1.1									1.5		3
Carya glabra	1.7	12.0	5.0		10.5	4.7						3.4	5.5	7
Juniperus virginiana	1.0	0.9	1.1		4.2	2.6	4.5	1.1			5.9	1.5	28.1	10
Total Species Found in Habitat Type	**60**	**62**	**75**	**7**	**40**	**31**	**25**	**54**	**47**	**20**	**20**	**60**	**21**	

3.2 Dominant Stratum

Row number one of Table 3.1 lists the dominant canopy life form (e.g. tree or shrub). The dominant canopy life form is the upper most layers (stratum) as observed from above. Six habitats are composed of trees, three by saplings and shrubs and two by herbs and grasses.

3.3 Dominant Canopy Species

There are four major life form strata comprising each habitat; trees, shrubs (including tree saplings), vines and herbs (including grasses). Trees generally dominate the upper-most layer (the canopy) where time since disturbance has been sufficient to allow unimpeded growth. Shrubs and saplings form the next lower stratum (the subcanopy) under trees, or serve as the canopy in younger habitats. Vines occupy the trunks and branches of trees and shrubs or trail along the ground surface. Herbs (including grasses and tree, shrub and vine seedlings) occupy the ground surface and are generally less than four feet in height.

Dominant species for each stratum are listed in rows 2, 9, 10 and 14 of Table 3.1 by USDA codes, which are based on abbreviations of the scientific names (Appendix C Species List). Only the four top-ranked species are listed for each habitat type. Ranking is based on calculated importance values. Table 3.9 presents an example of the top ten species for the tree canopy habitats by common name and importance value (IV), along with a count of the frequency that the species occurs as a dominant species throughout the study area.

Table 3.9 shows 33 tree species that form the dominant canopy strata throughout the different habitats in the study area. Red maple and sugar maple are the most commonly occurring dominant species, present in five of the six tree dominated habitats. The propagules of both maples are wind transported, thus arrive to an open site early in the successional process. Sugar maple tends to persist as the forest matures, as may be observed by its high IV in oak-hickory forest. Red maple generally gives way to competitors, as may be seen by its low IV in all habitats. Sugar maple is strongly dominant in both the bottomland hardwood forest and the mixed mesic forest. Species with IVs of greater than 40 have the strongest site presence and include sugar maple, white oak and American sycamore.

White oak, while present in three habitats is only dominant in the oak-hickory forest type. The oak-hickory forest is composed of six primary species of oak and three primary species of hickory. Sugar maple and American beech are common but not dominant in the oak-hickory forest.

Native pine forest is almost a monoculture of Virginia pine, while planted pine is composed of almost exclusively eastern white pine.

Table 3.9 Tree Canopy Habitat Species and Importance Values

Species	Bottomland Hardwood Forest	Mature Oak-Hickory Forest	Mixed Mesic Forest	Native Pine	Palustrine Forested Wetland	Planted Pine	Frequency
Red Maple	11.7		8.1	13.7	29.5	12.8	5
Sugar Maple	57.4	38.6	79.6	18.8	10.2		5
Black Walnut	20.4		10.2		29.1		3
Flowering Dogwood			9.8	14.1		12.4	3
Green Ash	8.4				12.3	17.7	3
White Oak		55.1	9.6	12.3			3
Wild Black Cherry	12.8		18.4		12.0		3
American Beech	18.7	12.1					2
American Sycamore	24.5				43.9		2
Eastern White Pine				15.1		104.4	2
Mockernut Hickory		8.1		10.0			2
Pignut Hickory		15.5		12.3			2
Sassafras			14.0	14.8			2
Shagbark Hickory		23.5	14.1				2
Silver Maple	9.0				28.9		2
Tulip tree	11.3		23.4				2
Black Locust			9.0				1
Black Oak		21.4					1
Blackjack Oak		16.0					1
Boxelder					20.5		1
Chestnut Oak		17.7					1
Common Persimmon						12.6	1
Eastern Cottonwood					13.2		1
Eastern Red cedar				10.5			1
Honey locust						17.0	1
Northern Red Oak		16.0					1
Pawpaw	20.6						1
Red Pine						110.3	1
River Birch					21.6		1
Scarlet Oak		8.9					1
Slippery Elm	15.6						1
Sweet Crabapple						12.7	1
Virginia Pine				90.5			1
Dominant Count:	**33**						

3.4 Age of Stand

Average age of the various habits is calculated using ring counts from core data obtained using an increment bore. Cores were obtained from trees at all plots within each forested habitat type. Table 3.1 row three lists the average ages of the canopy layer for each habitat. These data may not represent the actual age of stands, particularly the older (larger diameter) forests due to the increment bore length limitation. Many larger trees could not be cored, but these were relatively few as may be seen by the range of average diameters. Trees that could be cored ranged in age from nine years for a specimen in the palustrine forested wetland to 274 years for a likely fence-line specimen in the oak-hickory forest. The former germinated in 2000, while the latter germinated in 1737. The average age of all forests is approximately 60 years, resulting in the average tree germinating in 1951. This latter date possibly correlates with the acquisition of the PORTS reservation by the federal government and its abandonment for use as pasture.

Age data can present a picture of successional history since disturbance. The oldest average forest age is 86 years for the oak-hickory forest, suggesting that a majority of the forest had been removed in the 1920s. By the time the PORTS reservation was under acquisition, agricultural uses had constricted to easy access ridgetops and the more fertile north-facing slopes and bottomlands. Forest types in moist areas average 63 years in age, which would place their abandonment in approximately 1948. The least fertile ridge top habitats required an additional ~20 more years for Virginia pines to become established in approximately 1966.

Age is considered here as the time since the last significant disturbance occurred in a forested stand. Age correlates well with many of the other measurable characteristics in this study. Table 3.10 presents the correlation of other characteristics and values listed in Table 3.1. Correlation values range from -1.0 to 1.0. The closer the correlation to 1.0 the more likely that time since last significant disturbance of a specific habitat is important in the increase in a value or characteristic. The closer to -1.0, the more likely that time leads to a decrease in magnitude of the characteristic or value. The closer the correlation to “0” the greater the likelihood that factors other than time or age of stand influence the magnitude characteristic or value.

Correlations generally support present expectations the changes in habitat structure and composition between time and the biological processes of natural succession.

Table 3.10 Time-Age Related Corollaries with Other Measured Characteristics and Values

Habitat	Correlation	Interpretation
Canopy Height	0.89	Tree canopy height increases with time
Average DBH	0.88	Mean tree diameter increases with time
C of C Index	0.84	The C of C is strongly affected by time since last disturbance
Tree Basal Area/acre	0.79	Basal area increases with time
Woody Basal Area	0.79	Total basal area increases with time
FQAI	0.66	The FQAI is strongly affected by time since last disturbance
Number of species	0.64	The number of species increases with time
Nativity Index	0.48	Nativity increases moderately with time
Tree Count	0.43	Tree stem density increases moderately but decrease with time
Shannon's Diversity	-0.21	Diversity decreases only slightly with time as fewer species become more dominant
Simpson's Heterogeneity	-0.25	Diversity decreases only slightly with time as fewer species become more dominant
Total Stems/acre	-0.26	Stem density decreases with time as fewer but larger stems become established
Growth Rate Trees	-0.40	Growth rate as the fraction of total stem diameter decreases with time
Average % Ground cover	-0.69	Ground cover density decreases with time as canopy density increases
Growth Rate Subcanopy	-0.78	Subcanopy growth rate strongly decreases with time due to canopy layer density and tree competition

3.5 Site Occupation: Tree Size and Biomass

The magnitude of vegetation biomass and the size of the individuals comprising a habitat are characteristics important to forestry and wildlife management. Rows four and five of Table 3.1 present the tree diameters and canopy heights for the vegetated habitats. Site occupation includes concepts of density as stems per unit area, ground cover density and biomass as area of woody material per unit land area (generally square feet of wood per acre). Rows 6, 7, 11, 12 and 15 from Table 3.1, list these characteristics.

Tree characteristics of significance include canopy height, stems density, basal area and stem diameter. Figure 3.1 shows the relationships between these characteristics for the forested habitats on and near the PORTS reservation. Stem counts and basal area includes both trees and saplings less than eight inches dbh. These data show, for example, that the site would be greatly overstocked if forest products output maximization were a management objective. The Upland Central Hardwood Stocking Guide (Roach 1977) indicates that tree stands with a 14-inch diameter class should be occupied by 125-150 trees per acre, yielding a basal area in square feet per acre of 140 to 150. Wildlife management for many birds and quadrupeds is, however, greatly facilitated by overstocked forest due to generally greater denning opportunities (branch cavities, hollow trunks, etc.) that accrue as a forest ages.

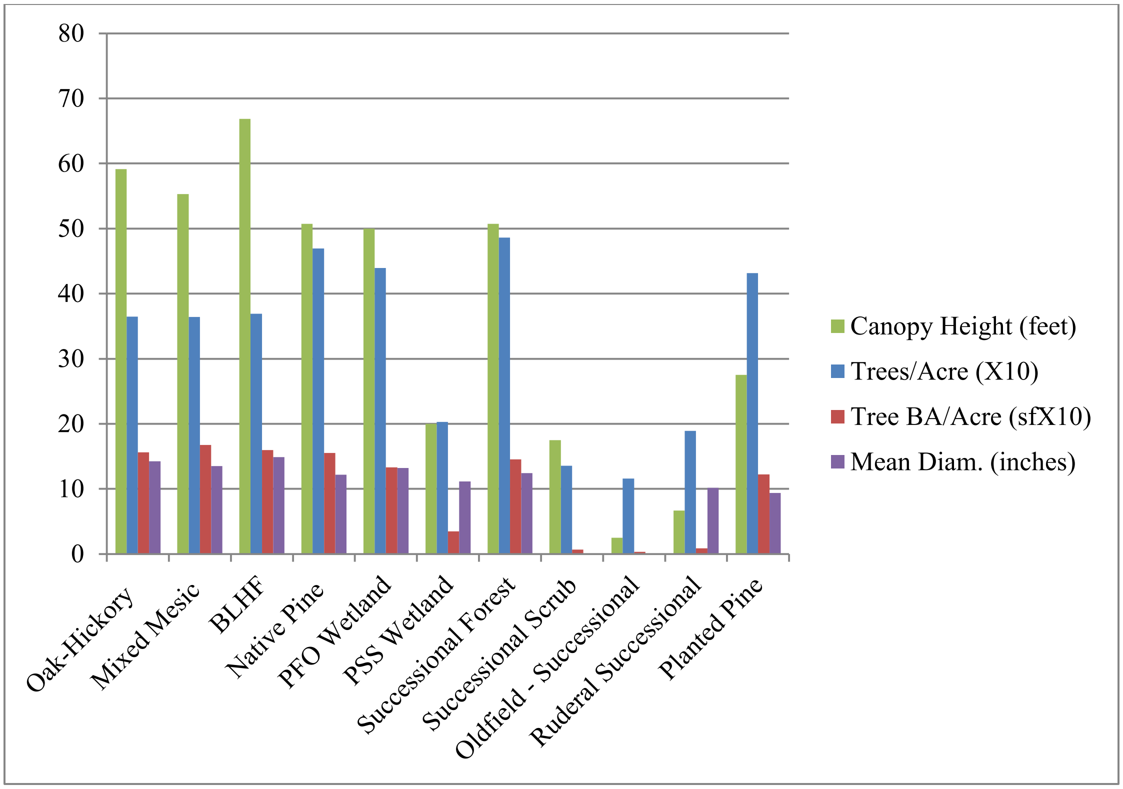

Figure 3.1 Site Occupation and Site Characteristics for PORTS Area Forests

The various strata of growing vegetation in a habitat occur in constant competition. Measurements for these strata should demonstrate competition through negative correlation based on one or more density or biomass measurements. Table 3.11 shows correlations between tree basal area and four growth or site occupation measurements.

Table 3.11 Tree Biomass Correlation

Occupation Factor	Correlation
Non-Tree Stem Count	-0.005
Growth Rate Subcanopy	-0.353
Non-tree Basal Area	-0.210
Average % Groundcover Density	-0.895

Correlations are calculated across vegetated habitat types. Non-tree stem count is weakly negatively correlated, which suggests that reproduction is good. The stronger negative correlations with subcanopy woody growth rate and non-tree basal area show the effect of competition between the strata. Groundcover density is strongly negatively correlated with tree basal area because tree basal area is strongly positively correlated with canopy density; competition for sunlight.

3.6 Growth Rate of Woody Vegetation

Growth rate has been calculated using tree core samples collected using an increment bore and from stem cross-sections (rows 8 and 13 in Table 3.1) using 121 cross-section cookie and 341 core samples were collected. Growth rate for trees (as stem diameter increase in inches per year) was derived by measuring and recording diameter of the tree to be cored and dividing by the number of growth rings. Shrub and sapling growth was measured by counting growth rings and dividing by the average diameter of the stem cross-section samples.

The growth rates for the shrub and sapling subcanopy was generally found to be significantly less than that for the canopy layer. The average ratio was found to be 2.6:1.0 for canopy to subcanopy growth rates. This would be expected due to competition for nutrients and sunlight between the two layers. The slowest subcanopy growth rate was found for the oak-hickory habitat subcanopy; the highest for the palustrine shrub-scrub wetland type. This suggests that water availability played an (xeric slopes versus wetlands) important role in the difference. The highest growth rate for the canopy species was for planted pine, which is almost entirely composed of the fast-growing eastern white pine. Wetland habitats measured highest for natural habitats for growth rate. This characteristic suggests that the wetlands from which samples were collected support only seasonal wetland hydrology (probably springtime) and are well aerated during the majority of the growing season.

3.7 Dominant Shrubs and Saplings

Table 3.12 lists 15 species of shrubs and one sapling (red maple) that were identified as dominants in three or more of the eleven vegetated habitats. Species are listed by importance value (IV) and ranked by frequency of occurrence. Shrub layer occupation is highly diverse and varies greatly with moisture conditions. (Note: the higher IVs for species in prime habitat). Paw paw and spicebush reach their peak in bottomland hardwood forest and mixed mesic forest. Sandbar willow dominates palustrine wetlands. Blackjack oak occurs most importantly in dry habitats such as oak-hickory forest and native pine stands.

Shaded rows represent non-native or invasive species. The top two ranked species are considered invasive. These tend to rapidly occupy sites and to exclude other species. Multiflora rose is a non-native species and a listed noxious weed. The third ranked species, shrubby St. Johnswort, is an invasive native that strongly dominants the understory in the mixed mesic forest and shrub-scrub wetlands throughout the study area.

Table 3.12 Most Frequently Occurring Dominant Species Occurring in the Shrub/Sapling Stratum

Species	BLHF	Mature Oak-Hickory Forest	Mixed Mesic Forest	Native Pine	Oldfield - Successional	Palustrine Emergent Wetland	Palustrine Forested Wetland	Palustrine Shrub-Scrub Wetland	Planted Pine	Ruderal Successional	Successional Forest	Frequency
Allegheny Blackberry	6.6	20.6	14.5	13.5	13.5	13.4		24.5	17.8		21.0	9
Multiflora Rose	70.2		57.6		21.3	64.2	93.8	19.1	12.5	12.7	56.1	9
Shrubby St. Johnswort	13.1		12.2		90.7	10.8		49.9	12.5	33.5	25.4	8
Flowering Dogwood	9.6	10.4	8.6		10.9		7.2		40.6	20.4		7
Green Ash	10.4		11.3	18.7	6.9	32.7	34.2		41.7			7
Pawpaw	37.2	20.3	49.6				14.7				23.3	5
Bush/Amur Honeysuckle			14.4				22.5		35.4		9.1	4
Northern Spicebush	50.7		15.8				16.3				19.9	4
Round-leaf Greenbrier	7.7	23.5	13.7	26.2								4
Russian Olive			4.7				19.4	8.7	56.8			4
Sassafras		19.0	16.4	25.1							17.1	4
Common Persimmon					9.9				20.4	10.0		3
Blackhaw			5.8				6.1	8.8				3
Blackjack Oak		15.6	3.0	21.5								3
Red Maple					54.4	16.3	24.5					3
Sandbar Willow						91.5		27.9		27.6		3

3.8 Dominant Woody Vines

Vines occupy the ground surface, tree stems and may climb sufficiently high to compete for light with trees and saplings. There were eleven species of woody vines found within the study area. Two, in shaded rows of Table 3.13 are invasive non-native species. Japanese honeysuckle was recorded as a strata dominant in all habitats except native pine. It is observable in all edge habitats throughout the study area.

Table 3.13 Most Frequently Occurring Dominant Species Occurring in the Woody Vine Stratum

Species	BLHF	Mature Oak-Hickory Forest	Mixed Mesic Forest	Native Pine	Palustrine Emergent Wetland	Palustrine Forested Wetland	Planted Pine	Successional Scrub	Frequency
Japanese Honeysuckle	47.02	77.39	58.22		64.96	78.36	77.69	226.47	7
Virginia Creeper	54.53	22.17	61.51	35.26	43.11	42.48	68.17		7
Poison Ivy	51.72	102.51	34.96	76.28	119.65	51.65			6
Riverbank Grape	55.33	7.79	11.49		41.78	57.87			5
Frost Grape		14.22	25.11			38.22	154.14		4
Summer Grape	38.49	41.40	78.26	188.46					4
Trumpet Creeper	8.10	9.11	10.63			8.42			4
Round-leaf Greenbrier	12.45	18.23			30.50				3
Bristly Greenbrier			2.73			3.26			2
Cat Greenbrier		7.19						73.53	2
Fox Grape			11.00						1

3.9 Dominant Herbaceous Stratum

The herbaceous stratum includes all specimens less than one meter in height and for this study area, is composed mostly of woody vines, shrub and saplings, as shown in Table 3.14. Invasive non-native species are in shaded rows. The most frequently occurring and dominant herbaceous layer species is again Japanese honeysuckle, a non-native invasive that is also a listed noxious weed.

Table 3.14 Most Frequently Occurring Dominant Species occurring in the Herbaceous Stratum

Species	BLHF	Mature Oak-Hickory Forest	Mixed Mesic Forest	Mowed Maintained	Native Pine	Oldfield - Successional	Palustrine Emergent Wetland	Palustrine Forested Wetland	Planted Pine	Ruderal Successional	Successional Forest	Frequency
Japanese Honeysuckle	5.23	5.54	11.87	10.33				8.91	20.33		20.51	7
Poison Ivy	6.49			11.23	10.11			6.89	12.43	14.59	16.17	7
Virginia Creeper	5.33	8.31	8.38		8.62			5.93	18.89		12.60	7
White Snakeroot	9.99		12.53					12.35	11.13		14.98	5
Green Ash	4.71		5.51		8.31				6.94			4
Northern Dewberry		7.07	5.11	21.85							7.44	4
Wingstem	7.14		4.73			4.88		13.48				4
Multiflora Rose	5.09		5.35					8.45				3
Red Maple		11.46			14.34				6.80			3
Sericea Lespedeza				8.93		10.39				29.53		3
Wild Black Cherry			6.18						7.28		3.92	3

3.10 Measures of Diversity

The concept of diversity is often linked to overall biotic community health, vigor and resilience. Species count Shannon‟s Index and Simpson‟s Heterogeneity, found in rows 16, 17 and 18 in Table 3.1, are all measures of diversity. Species count (sometimes called richness) is simply the number of different forms in a defined area of land or habitat type without consideration for the abundance of each species. It is a raw measure of niche diversity that is strongly linked to moisture availability, in terms of frequency of wetting of the substrate during the growing season. It is not surprising that the mixed mesic forest type had the highest species count; at least 25% greater than the next highest (BLHF) and more than double most other habitats. The lowest species counts were observed in the mowed-maintained, successional scrub and planted pine and ruderal types. The presence of disturbed, generally lower nutrient soils selects for the fewer species that can tolerate these stressful sites. Species that can tolerate mowing (and grazing) form their growth regions at or below that soil level, which favors the maintenance of grasses and other monocots. Pine stands are monocultures by design, usually beginning with a single species, planted at regular intervals and often with active suppression of other species as a management strategy.

Simple species count cannot assess such plant community structural characteristics as dominance, density, clustering and interspersion. Both Shannon‟s Index and Simpson‟s heterogeneity address the idea of individual species abundance and interspersion and require quantitative sampling to obtain abundance measurements for each species. The Shannon Index estimates the uncertainty (entropy) of being able to predict the species of the next individual randomly selected. Simpson assesses the probability the two species selected at random will be the same species, addressing both species abundance and interspersion. Both methods express their predictions as percentage based risk. A lower diversity system, like a cattail marsh, may approach a “0” value. A very diverse system of equally represented individuals will approach 1.0 (Figure 3.2).

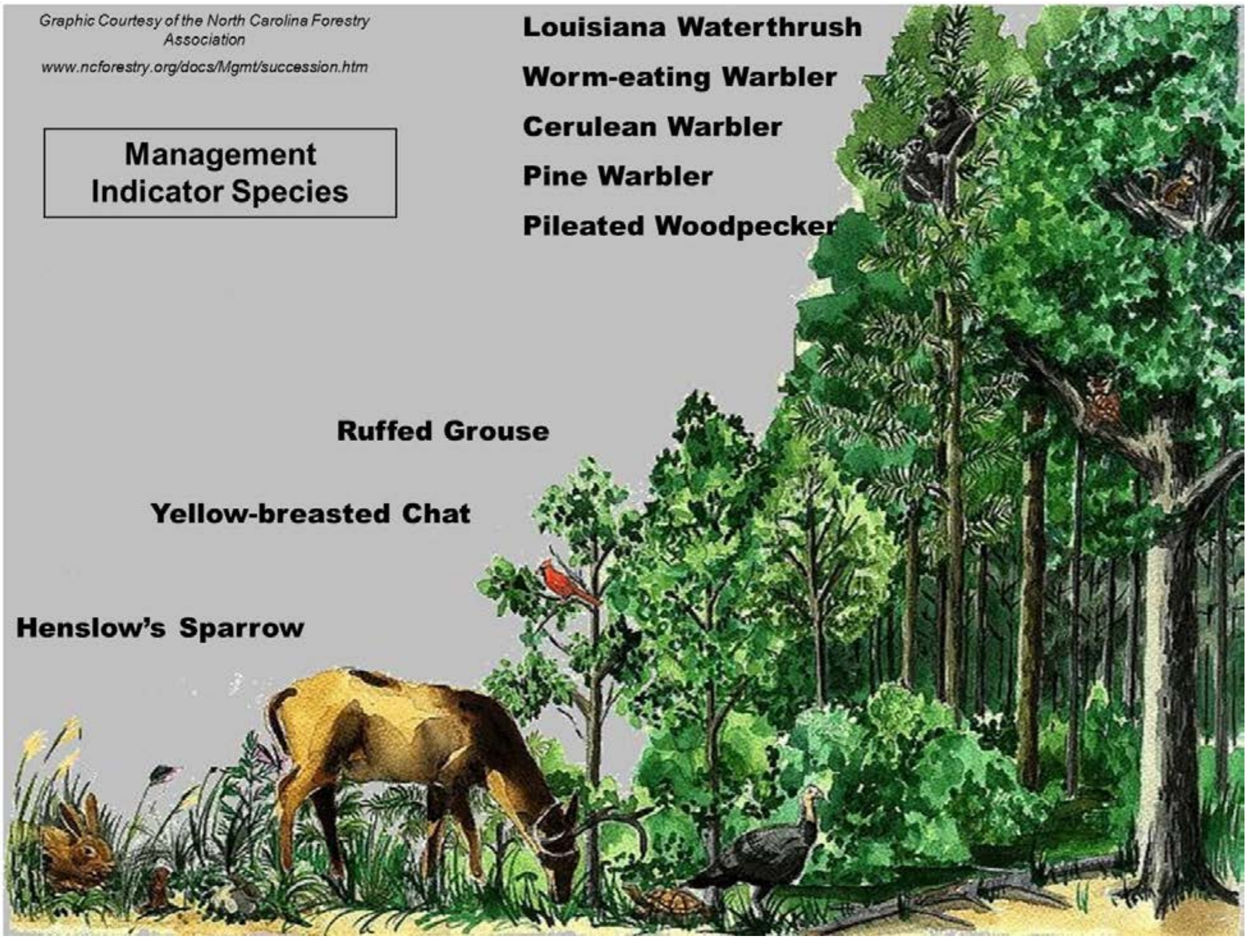

Figure 3.2 Example of changing habitats and species accumulation

3.11 Wetland Index

The wetland index (WI) is a weighted frequency analysis based on wetland indicator status as defined by Reed et al. (1988). Ratings of "1" are given for species with lifecycle needs for nearly perennial surface inundation and are rated to occur in wetlands at a frequency of more than 99%; obligate hydrophytes. Plants species rated "5" occur in wetlands at a frequency of less than 1%; obligate upland species. The wetland prevalence rating was designed to assess whether a define plant community is a wetland as defined under the Clean Water Act. Any community with a prevalence rating of equal to or less than 3.33 is a wetland community and would likely be regulated under the Clean Water Act as a "water of the United States". Three natural habitats mapped as wetlands demonstrated wetland indices of less than 3.33; palustrine forested, shrub-scrub, and emergent wetland habitat types. Several habitat types have wetland prevalence ratings of less than 4.0, which define habitat types that retain or receive water at a higher rate than surrounding areas, such as bottomland hardwood forest and mixed mesic forest. Smaller wetlands can often be found in low topographic depressions within these types. The highly and frequently disturbed "ruderal successional" mapping unit (Table 3.1) also shows a WI of less than 3.33. Wetland index ratings of greater than 4.0 characterize mature oak-hickory and native pine forest on dry ridgetops and south-facing slopes.

3.12 Nativity Index

The nativity index for vegetated habitats as shown on row 20 of Table 3.1 expresses the importance of native versus non-native and invasive species. The highest obtainable value is "5". All study area habitats demonstrate relatively high nativity values (greater than 4.0) and a mean value of 4.46. The lowest nativity rating was expectantly observed in planted pine stands (3.84). This is related to the scattered shading produced by white pine and a low area-to-perimeter ratio.

Nativity indices show that the vegetated habitats on the PORTS reservation and surrounding lands are principally composed of native species. Sample locations within mapped habitat polygons during surveys, rather than at the edge, results in an under-sampling of many of the weedy species as they often have a low shade tolerance and thus cling to edges. Nativity ratings as calculated include all species in the habitat type as a weighted frequency analysis. The trees, ranked highest in importance value and nearly completely represented by native species, mask the findings for nativity in the shrub, vine and herb strata. These strata assessed separately result in the following nativity ratings as compared to the mean value with the tree stratum included, as shown on Table 3.15.

Habitats, for which tree cover is suppressed such as powerline corridors, show the lowest nativity ratings.

Table 3.15 Nativity Indices by Strata

Stratum	Nativity Index
Shrub/sapling	3.63
Vines	3.71
Herbs	3.78
Mean with Trees included	4.46

3.13 Coefficient of Conservatism Value and Floristic Qualitative Assessment Index

These characteristics, as discussed in Section 2.5.7 are valuations based on scientific expectations for the rarity or commonness of occurrence of species. Rows 21 and 22 of Table 3.1 show these values. The Coefficient of Conservatism (C of C) rating for each habitat is the mean C of C value for each species present in the sample with 10.0 being the highest valuation of a habitat possible. While the FQAI itself is dimensionless, the higher the number the more unusual (and therefore greater conservation value) to the community to which it is applied. The two ratings show trends in the same direction that indicate the PORTS area vegetated habitats to be composed of a species composition that, while diverse, is ordinary or common; rather than rare and unique. The trends sometimes differ in direction. Mathematically, the difference is that a weighted C of C mean uses all species and their importance values. Importance value is based on frequency of occurrence and a measure of biomass or community presence. The FQAI as used by the State of Ohio excludes non-native species and does not consider importance value, which ranks areas perhaps higher than they should be from an ecological standpoint, particularly if a single rare specimen is found.

4.0 Example Application of Habitat Mapping

4.1 Introduction

The scope of this project included the gathering of data to characterize the habitats that exist within the study area. Data collected during the 2011-2012 field seasons for the PORTS habitat assessment project focused on the vegetative components of the sample plots. However, numerous observations were made concerning some of the features and conditions that may provide suitable habitat for wildlife as well as physical evidence of wildlife observed during the survey. A review of observed wildlife, signs of wildlife, and habitat features is provided in Appendix D of this report.

This section of the report provides examples of the utility of this dataset, in conjunction with other available data sources, to develop specific queries concerning wildlife for conservation management and planning concerns. The examples presented here employ the use of Habitat Suitability Index (HSI) Models that could be used to inform Habitat Evaluation Procedures (HEP). Numerous HSI models have been developed by the U.S. Fish and Wildlife Service over the past 30 years to include a range of species that are of conservation concern or essential to a given habitat. These models provide an opportunity to evaluate the quality of wildlife habitat over large areas and provide decision-makers with information necessary to improve, mitigate, or conseve habitat for potentially affected wildlife species.

4.2 Example Application: Habitat Suitability Index

One universally accepted method to evaluate the quality of wildlife habitat as it may exist or as it may be configured after some planned disturbance is the Habitat Evaluation Procedure (HEP). This method is selected here as an example of a direct use of the mapping and supporting data from this study, that PORTS may wish to employ in impact assessment for future land use changes. HEP was developed by the U.S. Fish and Wildlife Service (USFWS 1980, Schamberger *et al.* 1982) and evaluates the quality and quantity of available habitat for selected wildlife species or group of species. HEP provides information for two general types of wildlife habitat comparisons. One, the relative value of different areas at the same point in time, and two, the relative value of the same area at future points in time. By combining these two types of comparisons, the impact of proposed land and water use changes on wildlife habitat can be quantified. HEP describes habitat for selected wildlife species as a Habitat Suitability Index (HSI) with a value ranging from 0.0 (unsuitable) to 1.0 (optimal). This value may be multiplied by the area of available habitat to obtain Habitat Units (HUs) that may be compared in an assessment of loss or gain for some set of proposals. To calculate habitat value over a period of time, such as the life of a particular land use activity, Habitat Units may be averaged on a yearly basis to provide Average Annual Habitat Units (AAHU).

Habitat Suitability Index (HSI) models were first developed by the U.S. Fish and Wildlife Service to facilitate the application of HEP. However, decades of research on wildlife-habitat relationships have provided guidance to understanding the habitat requirements of wildlife species in greater detail for conservation and management applications. Based on the collective body of knowledge gained over the past few decades, HSI models have more recently been modified by the USDA Forest Service (Rittenhouse *et al,* 2007; Larson *et al.*, 2003; Tirpak, *et al.*, 2008) to accommodate landscape-level habitat assessments using GIS applications. These modified HSI models are designed for efficient assessments of habitat quality using widely available spatial data. The modified HSI models utilize generalized landscape data, but can be improved by the use of site-specific data similar to the type of data provided in this report.

The data collected during this project has been engaged to help facilitate the development of site-specific HSI Models for target species at PORTS and the surrounding area. However, the utility of individual HSI models is dependent upon the availability and quality of the data specific to each species‟ habitat requirements within the study area. The landscape-scale approaches more recently modified from the earlier HSI models (circa 1980‟s) have increased the complexity and usefulness of the outputs. The modified HSI models are utilized in this report to provide an example of how future assessments may be developed and operated.

The choice for use of a particular HSI model must consider ecological conditions, the biome, the array of species that are likely to be present and the species or group of species whose autecology best compares to the anticipated structural changes to the habitat. The data characterizing the PORTS reservation and vicinity were evaluated to determine which species, models, and data were available to create a meaningful and informative output. In order to accomplish this task, a series of decisions had to be made.

A list was created of all species in which any HSI model was available, whether recently revised, modified, or from original USFWS HSI publications. First, species whose native range did not include the study area were eliminated. From that list, species were removed based on the area of their individual habitat requirement. That is, if the patch size preference of a species exceeded the study area of this project, they were not considered for model development. This list of species represented those in which applicable HSI models could be created to inform potential conservation planning and management opportunities. Existing HSI models for each of the applicable species was evaluated for this report to determine which models were suitable for development. The search narrowed the species list to ten species for which modified HSI models were available to accommodate a spatial landscape-scale approach.

The modified HSI models developed for ten species of the Central Hardwoods Region by Rittenhouse *et al.* (2007) were chosen to provide an approach for evaluating two species of concern within the study area and the PORTS reservation using GIS tools in a spatial application. Models for the Indiana bat (*Myotis soadlis*) and the timber rattlesnake (*Crotalus horridus*) were developed for presentation in this report. These species were chosen because they address species that are already of conservation concern at PORTS, model inputs can be developed for application of the model, and they provide an informative example of the potential for future model development of other species that could be of conservation interest at PORTS.

4.2.1 Methods

The methods presented in the Rittenhouse *et al.* provide the basis for the approach presented here. They modified HSI models for ten species of concern for the Central Hardwoods Region of the U.S. to facilitate a landscape-level approach. These models were developed using a set of primary input data that was dervived from remote-sensed data sources, namely the Forest Inventory Analysis (FIA) data, land-use and land-cover data, and others. The primary inputs were raster-based stand age, dominant canopy species, general land cover, and ecological land type (ELT). The data in this report provides the basis to create similar inputs for model development of these same ten species as well as many others. This section of the report describes the development of these primary inputs.

An HSI model for an individual species is built upon a set of discrete habitat suitability requirements that are expressed as Suitability Indices (SI‟s). Each SI is calculated based on a set of conditions applied to each primary input as a type of multi-criteria decision analysis (MCDA). For any given species, there are known habitat criteria that either favor or inhibit the suitability for a stable population to exist. These criteria provide the basis in which each SI is calculated.

In the MCDA process, criteria are scaled from 0 to 1. While “0” represents no suitability and 1 indicates optimal suitability, the range of values in between reflects a gradient of conditions that a species may find suitable. A final HSI value is assigned to each raster cell based on the specific model calculation for each species. Using gridded raster data (see Figure 4.1), this approach can be performed in a spatial manner, creating a map that illustrates the distribution of suitable habitats.

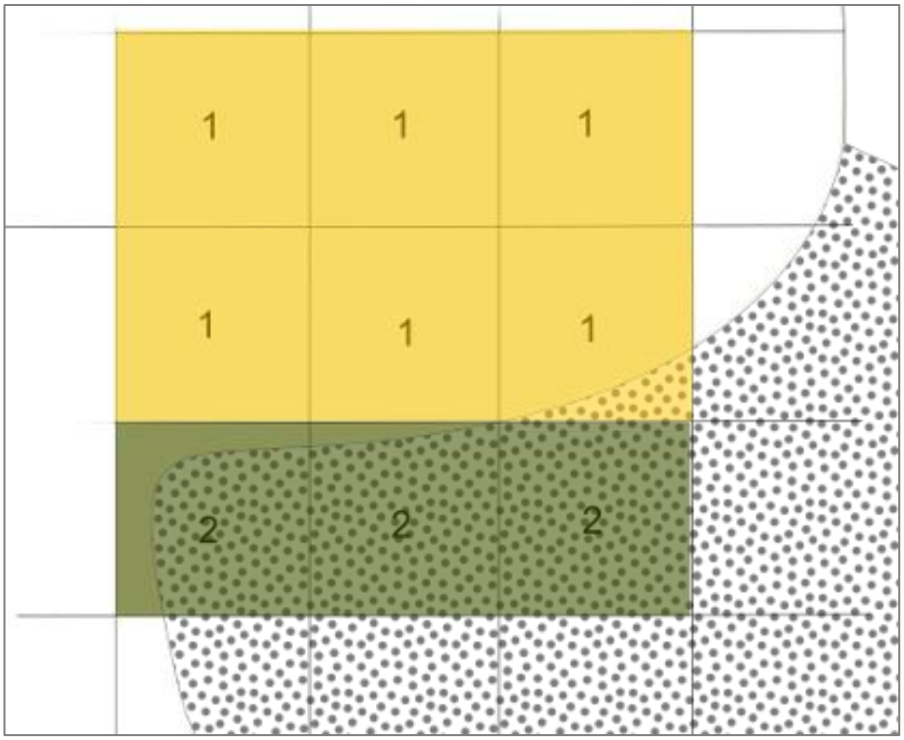

Figure 4.1 Example of grid sampling

While an HSI model does not predict the presence of a species, it can predict the quality of a habitat for a given species based on resource availability and habitat requistes. Even if the habitat is deemed suitable, there exists little guarantee that the species will be present. However, if a species is suspected to be present in an area, the model result could provide essential guidance to determine where that species might be found and how it may be affected by changes in management and land use.

4.2.1.1 Input Data

The HSI models relied on four primary sources of input data including:

- Forest stand age
- Dominant forest canopy species
- Land cover type
- Ecological land type (ELT)

These datasets did not exist previously and were generated using a combination of freely accessible information and data collected or created for the habitat mapping project. Sources of data used in this process included:

- Vegetation plot sampling data collected in the field to support habitat mapping
- Habitat cover: delineated habitat classification
- Pike County Location Based Response System (LBRS): The centerline location of all public roads in Pike County, Ohio to a precision of 2 feet
- National Hydrography Dataset (NHD): A national dataset of water bodies, streams, and drainage systems
- Light Detection and Range Elevation Data (OSIP LiDAR): LiDAR is a collection of dense points collected using an aerial mounted laser system. LiDAR datasets provided by the state of Ohio

were from missions flown in 2006-2007. For each point, at a spacing of about every five feet, two distances are recorded. These are called first and last returns and represent the object hit both closest and farthest from the aircraft. First returns generally are from tree tops, power lines, and the occasional bird. Last returns are always large solid objects and can be the surface of the earth, rocks, buildings, and the base of large trees. The difference of these is a good approximation for the height of canopy trees in known forested areas, as shown in Figure 4.2.

- Digital Elevation Model (OSIP DEM): published by the Ohio Statewide Imagery Program (OSIP), the DEM provides the elevation of all locations in the study area with a spatial resolution of 2.5 feet (see Figure 1.4). Data was post-processed statewide with the assistance of the United States Geological Survey from the LiDAR data.

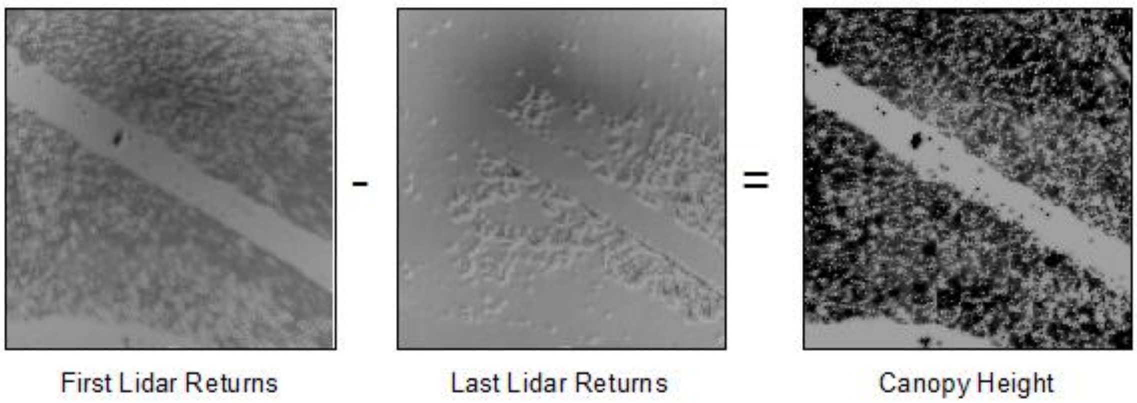

Figure 4.2 Example of height derivation from lidar digital elevation models

4.2.1.2 Ecological Land Type (ELT)

The ELT primary input dataset was derived from six distinct classifications to divide the land surface into units that distinguish the types of ecological conditions present within the study area. The ELT classification follows Van Kley *et al.* (1994) to group types by slope, aspect, and relative moisture. The ELT"s include: dry ridges, mesic ridges, bottomlands, south and west slopes, north and east slopes, and open water. Since the topographical nature of the region used to develop these models was somewhat different than the topography present in southern Ohio, minor adjustments to the definition of these ELT's had to be made. Table 4.1 outlines the criteria and definitions used to divide the study area into ELTs.

4.2.1.3 Forest Stand Age

While Rittenhouse *et al.* used FIA data for stand age; this example utilizes data collected during this study to formulate this primary input. Forest stand age was created by manually reclassifying the habitat cover dataset using field collected tree cores and LiDAR estimated canopy heights as guides. The estimates were produced by considering all available data and forest age was classified into groups of ten years. Non-forested habitats, based on the coverage in this report, were classified as 0 years of age.

4.2.1.4 Land Cover Type

Six basic land cover types are used to develop the generalized land cover type primary input including: forest, cropland, grassland, water, urban, and road. All of these types were obtained by reclassifying, or grouping, the habitat cover classifications in this study into one of these basic types.

Table 4.1 ELT classification and description

Code	ELT	Description
1	Dry ridges	Locations that were not identified as bottomland, where the slope was <10%, and the curvature of the surface indicated it to be a narrow ridge or hill top
2	South and west slopes	Locations with a general aspect of south or west and slope >10%
4	Mesic ridges	Locations that were not identified as bottomland, where the slope was <10% and the curvature of the surface indicated it to be a wide flat ridge or hill top
5	North and east slopes	Locations with a general aspect of north or east and slope >10%
6	Bottomlands	Locations where bottomland habitats were observed whose elevation was lower than the average elevation of the local area and the curvature of the surface indicates it to be a valley
7	Open water	Locations delineated as open water in the habitat coverage

4.2.2 Sources of Error or Uncertainty

Models were performed using ArcGIS model builder to construct and refine the model process (Figure 4.3). This allowed simplified model runs to accommodate changes made to the input data, making the models both repeatable and efficient. The necessary input data were either digitized by hand, or derived in the model from one of the sources listed in the next section. All data were sampled using a 15-foot square grid and computations performed using this pre-determined geometry.

Reducing the landscape to a finite grid for the purpose of calculation in itself introduces a source of uncertainty. Any phenomena or object that is smaller in size than about two times the size of the grid cells will not be captured in the process. For example, if a sub-grid sized pond exists within a calculation area, then the pond would not contribute to that calculation causing an error to be introduced into the model that does not reflected in the real world accurately (Figure 4.4). In these examples, a 15 foot by 15 foot grid cell was used in some of the calculations.

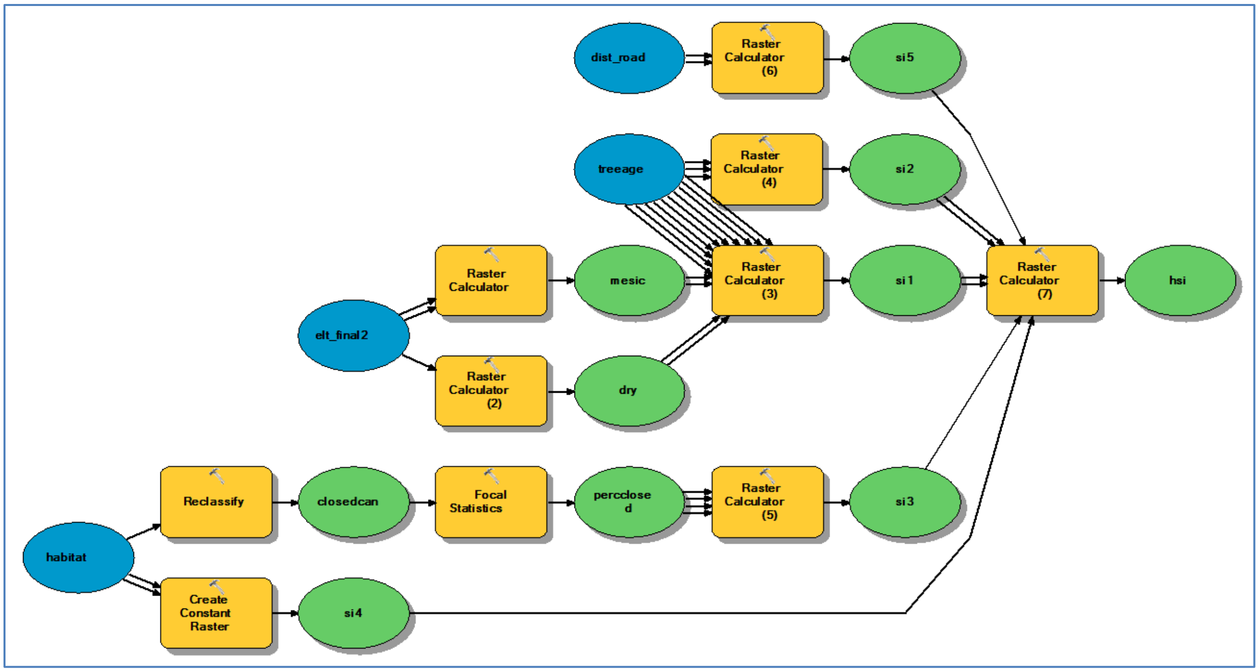

Figure 4.3 Example of Model Builder

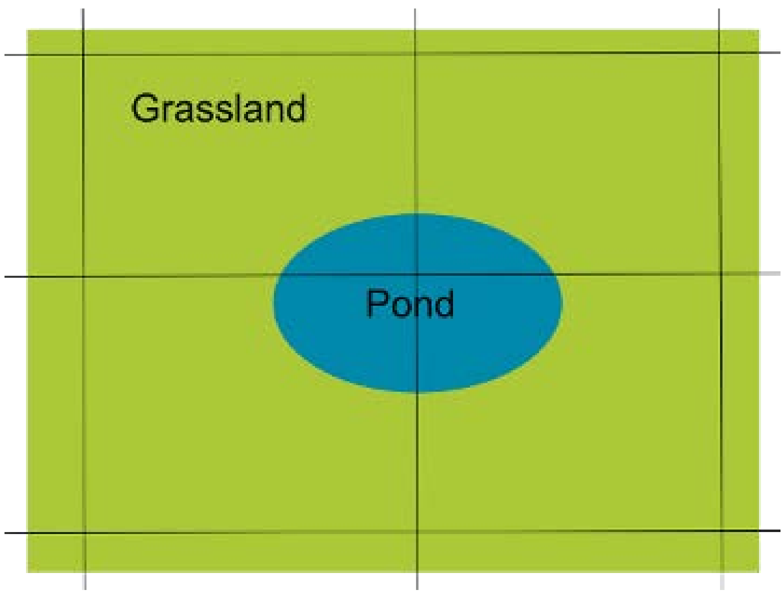

Figure 4.4 Example of sub-grid phenomena

Another source of error when using gridded data can be the grid itself. The boundaries of grid cells will not exactly correspond to the boundaries of features the cells represent. The shape and position of landscape features have to be slightly modified into a grid structure, often introducing some uncertainty to the edges of these features.

The estimation of age for a section of forest provides one item of model uncertainty as well. The older a forest is, the more difficult it becomes to estimate its age. This is a result of the dynamic nature of a forest and the constant turnover of older individuals with younger ones. However since the HSI models used in this report give importance of forest age only up to a certain limit, as the age of the forest no longer increases the suitability for wildlife species, this impact is minimized.

Some calculations in the models use a neighborhood analysis, that is, they do not rely on only the central grid cell being evaluated but rather considers its many neighbors, as represented in Figure 4.5. A good example of this is demonstrated in the timer rattlesnake HSI, where one of the SI criteria was 85% forest and 15% grassland in an 850-meter circular area. Near the edges of the study area, data did not exist beyond the boundary. Since the features outside the boundary are not accounted for, the information within is not known. As a result, these neighborhood calculations cannot take this into account, and only represent the conditions inside the area at locations where the neighborhood would extend outside the area. Unless the pattern of the landscape is completely homogeneous, these values may not be correct. The study area of this project is large enough that neighborhood calculations of cells on DOE property are not impacted; results near the edge of the study area should be viewed with caution.

Other sources of error can include misclassification, model bias/inaccuracy, and computer rounding errors. If an error exists from one of the above, continued mathematical operations will propagate these errors, and in some extreme cases compound them into misleading results.

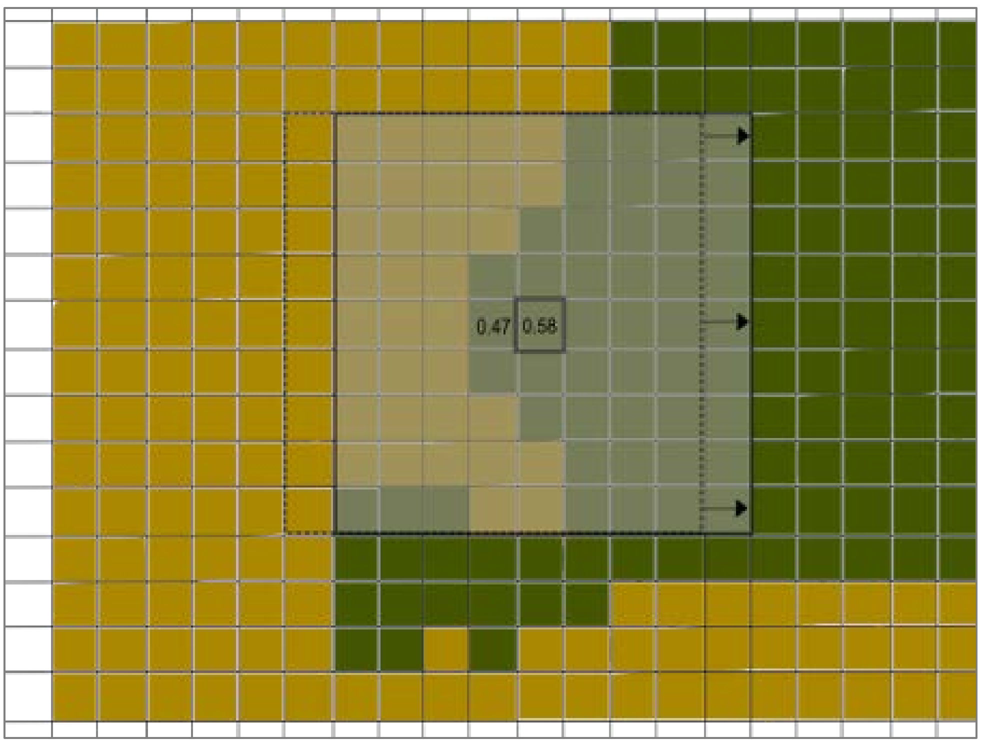

Figure 4.5 Example of neighborhood process evaluating the percent forest (green cells) of a cell from its neighborhood (shaded region)

4.3 Example HSIs

Two Habitat Suitablility Index (HSI) models were chosen to demonstrate the potential utility of the data presented in this study for evaluating the habitat suitability of certain species of interest. Modified HSI models based on Rittenhouse *et al.* (2007) were developed for the Indiana bat and timber rattlesnake. These species were selected because they are already of conservation concern at PORTS and southern Ohio, model inputs could be developed for application of the model, and they provide an informative example of the potential for future model development of other species that could be of conservation interest at PORTS.

4.3.1 Indiana Bat (Myotis sodalis)

The Indiana bat has been listed by the USFWS since 1967 as a federally endangered species. The PORTS reservation is within the native range of the Indiana bat and suitable habitat is already known to exist in the northwestern portion of the site (DOE 1996). With recent devastating declines in the population of Indiana bats due to White-nose Syndrome (WNS), conservation and improvement of quality bat habitat is paramount. The presence of WNS was confirmed in bat populations in Lawrence County, Ohio in surveys conducted in 2010-2011 (ODNR 2011).

4.3.1.1 Suitability Indexes (SI)

The Indiana bat has been widely researched (Romme 1994) to develop a comprehensive model to facilitate meaningful conservation of the species. The modified HSI used here was very well informed by the efforts of previous workers. The Indiana bat HSI is calculated using four suitability indices (SI) (Figure 4.6):

The first suitability index (SI_1) in the Indiana bat HSI represents a measure of the presence of suitable maternity roost trees. These trees, containing loose bark and holes, are often estimated using snag density data. Since older forests presumably host a greater number of suitable snags, the first suitability index (SI_1) is calculated using a function of tree age. Older forests become more suitable for habitat until about 100 years of age. The resultant SI identifies the older forests based on this calculation.

The second index (SI_2) identifies open areas or young forest stands in which the Indiana bat can forage for food. This SI represents a rather large area within the PORTS reservation.

The third index (SI_3) represents those areas within one kilometer of perennial waters. It is widely accepted that this species requires perennial water sources within one kilometer of any potential roosting habitat. Since the entire study area is comprised of dendritic drainage system occupied by perennial streams, the entire study area is considered to be within a kilometer of perrenial water.

The fourth index (SI_4) reflects that the species prefers to nest in roosting areas that can receive direct sunlight. These are estimated by treating the edges of larger forests (SI_1) next to open areas (SI_2) as increased suitability.

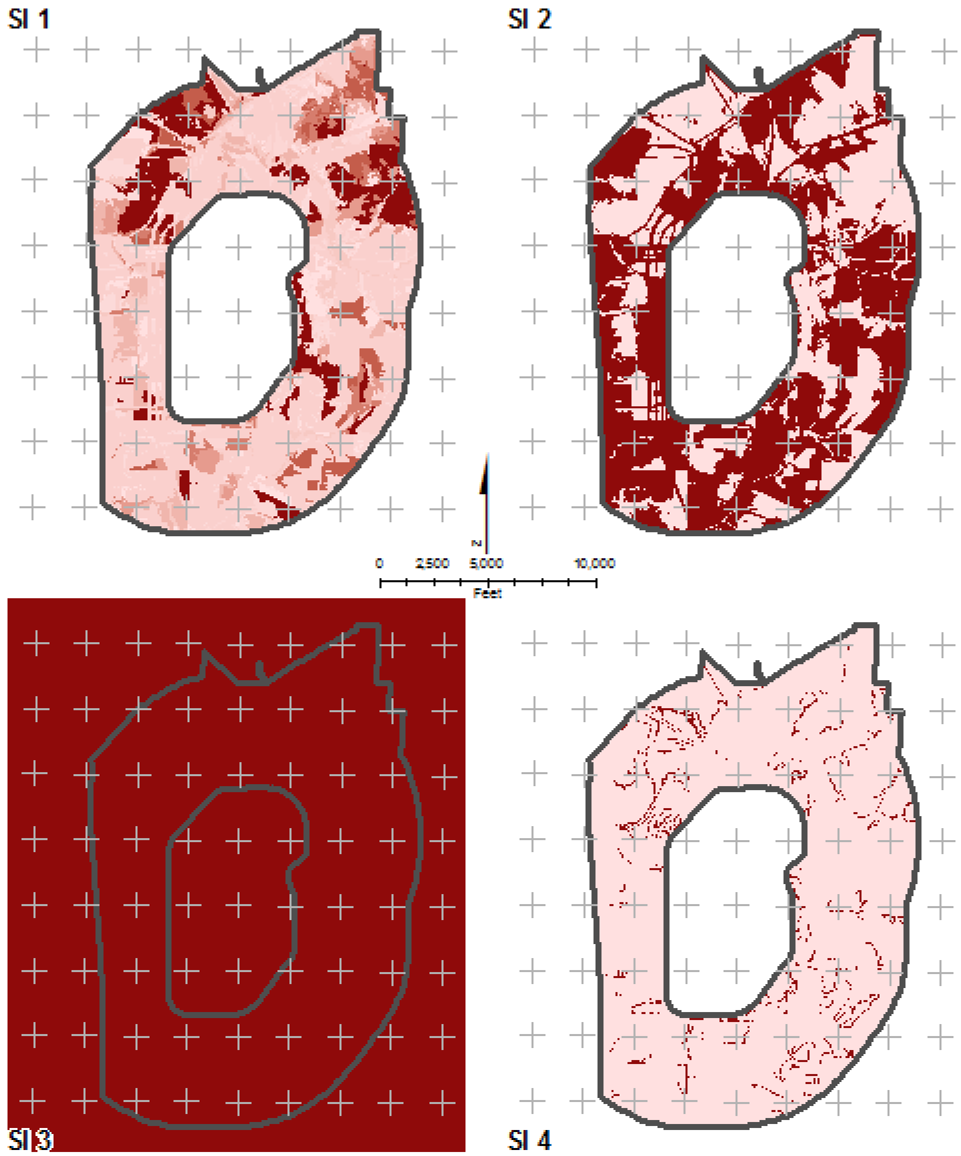

Figure 4.6 Indiana Bat SIs, Darker Shading Denotes Higher Suitability

4.3.1.2 Habitat Suitability Index

The final Indiana bat HSI calculation is a combination of the individual SI‟s using the following equation:

$$HSI = \left(SI_4\sqrt{SI_3\left(SI_1 \bigvee SI_2\right)}\right) \bigvee \left(\frac{SI_3}{2}\left(SI_1 \bigvee SI_2\right)\right)$$

The symbol „V" denotes the maximum value between the values compared on either side of the „V." For example, $SI_1 \vee SI_2$ would result in SI_1 if it is the larger value, otherwise it would result in SI_2.

The result of this analysis is shown in Figure 4.7, where higher indices represent higher suitability.

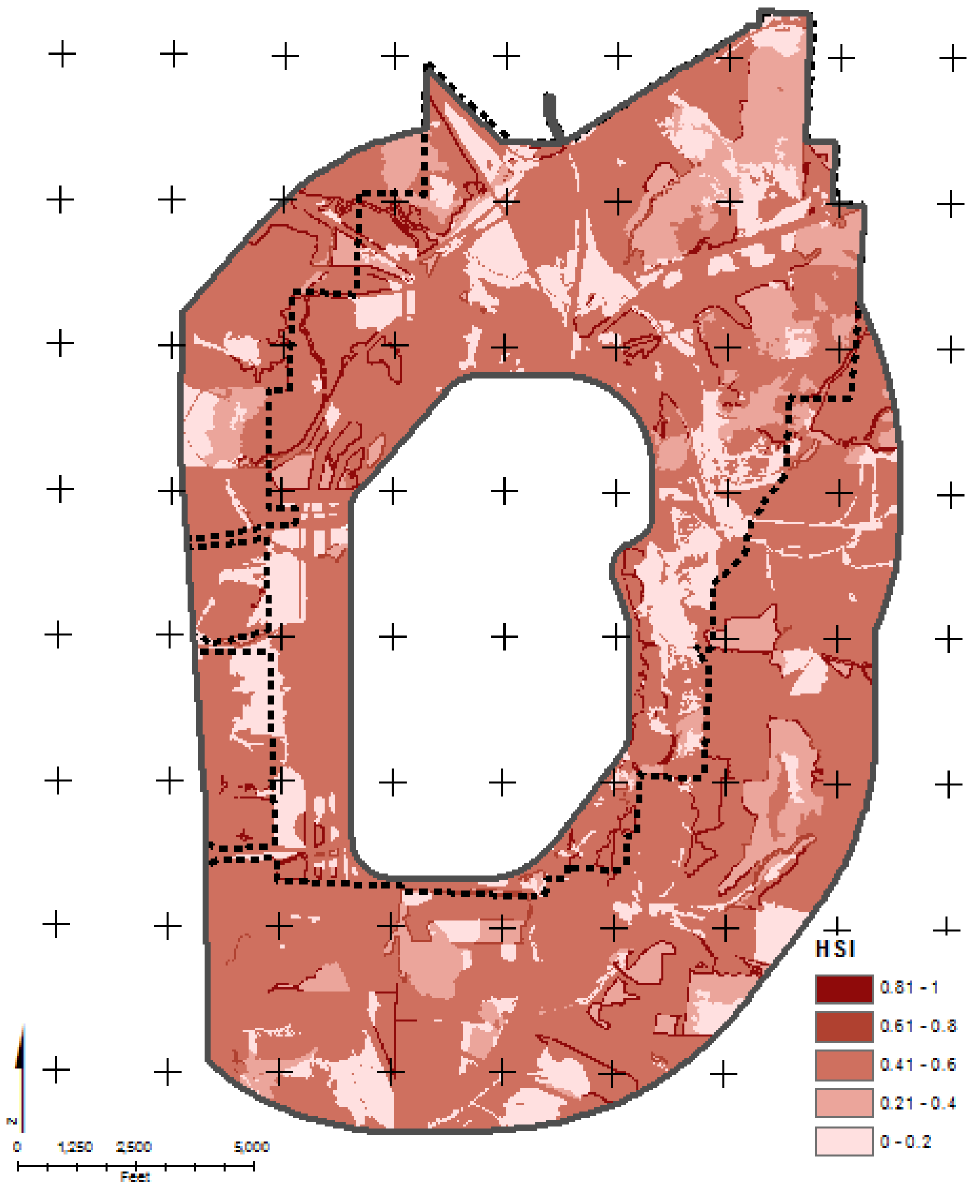

Figure 4.7 Indiana Bat HSI, Darker Shading Denotes Higher Suitability

4.3.2 Timber Rattlesnake (Crotalus horridus)

The timber rattlesnake is the second species of interest for model development using the modified HSI (Rittenhouse *et al.* 2007). The timber rattlesnake HSI was calculated based on five suitability indices (SI) (Figure 4.8). However, one suitability index, the distance to known dens of timber rattlesnakes, could not be calculated. Since the current study did not search for dens and no known dens exist, this HSI was calculated to represent the habitat suitability index as if there were dens nearby.

4.3.2.1 Suitability Indexes (SI)

Five suitability indices (SI) were incorporated to calculate the HSI for timber rattlesnakes:

The first suitability index (SI_1) for the timber rattlesnake is a measure of the potential habitat for prey species. Since their prey forage in young forests or successional habitat, SI_1 is greatest for all habitats with a forest stand age of less than forty years, adjusted for growth by ecological land types (ELT). The younger a forest is and the more mesic the land type, the greater the suitability index.

The second index (SI_2) is a linear function of tree age to represent the quality of habitat used for cover. A forest stand‟s age had to be at least 30 years old to qualify for inclusion in SI_2.

The third index (SI_3) is calculated to find areas in which the proportion of cover and foraging habitat are ideal. The ideal proportion is 85% forested and 15% open area within 850 meters of a given location.

The fourth index (SI_4) is not included in this example. In the source document, this SI is based on known distance to den locations. Since no known den locations exist in the study area, SI_4 was not calculated and did not contribute to the final HSI.

The final index (SI_5) is meant to consider the impact of ecological sinks. Considering that roadways can be a death zone for snakes, any area within 100 meters of a road can be considered unsuitable.

4.3.2.2 Habitat Suitability Index

The final timber rattlesnake HSI calculation is a combination of the individual SI‟s using the following equation:

$$HSI = SI_5\left(\sqrt{SI_3\left(SI_1 \bigvee SI_2\right)}\right)$$

The symbol „V" denotes the maximum value between the values compared on either side of the „V". For example, $SI_1 \vee SI_2$ would result in SI_1 if it is the larger value, otherwise it would result in SI_2.

The result of this analysis is shown for the study area in Figure 4.9, where higher indices represent higher suitability.

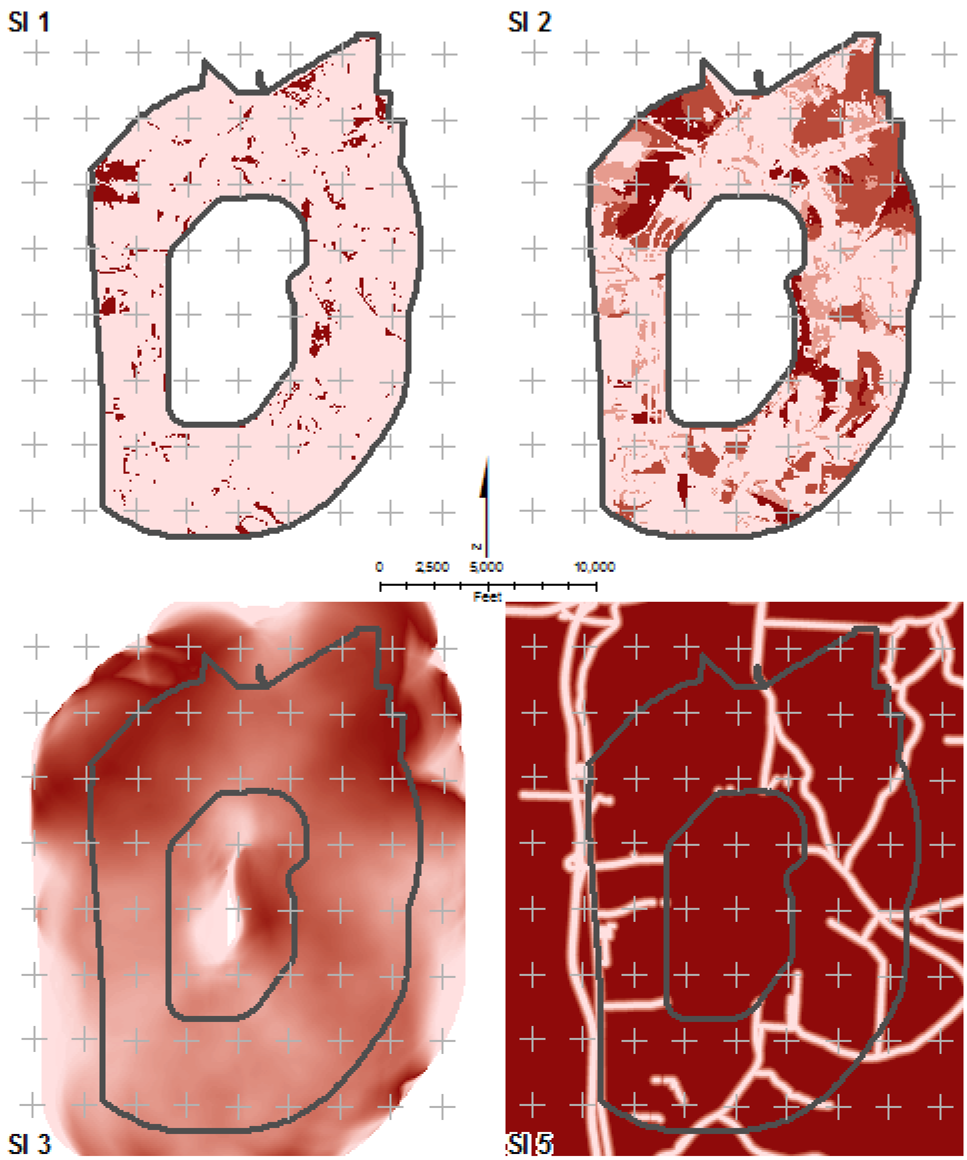

Figure 4.8 Timber Rattlesnake SIs, Darker Shading Denotes Higher Suitability

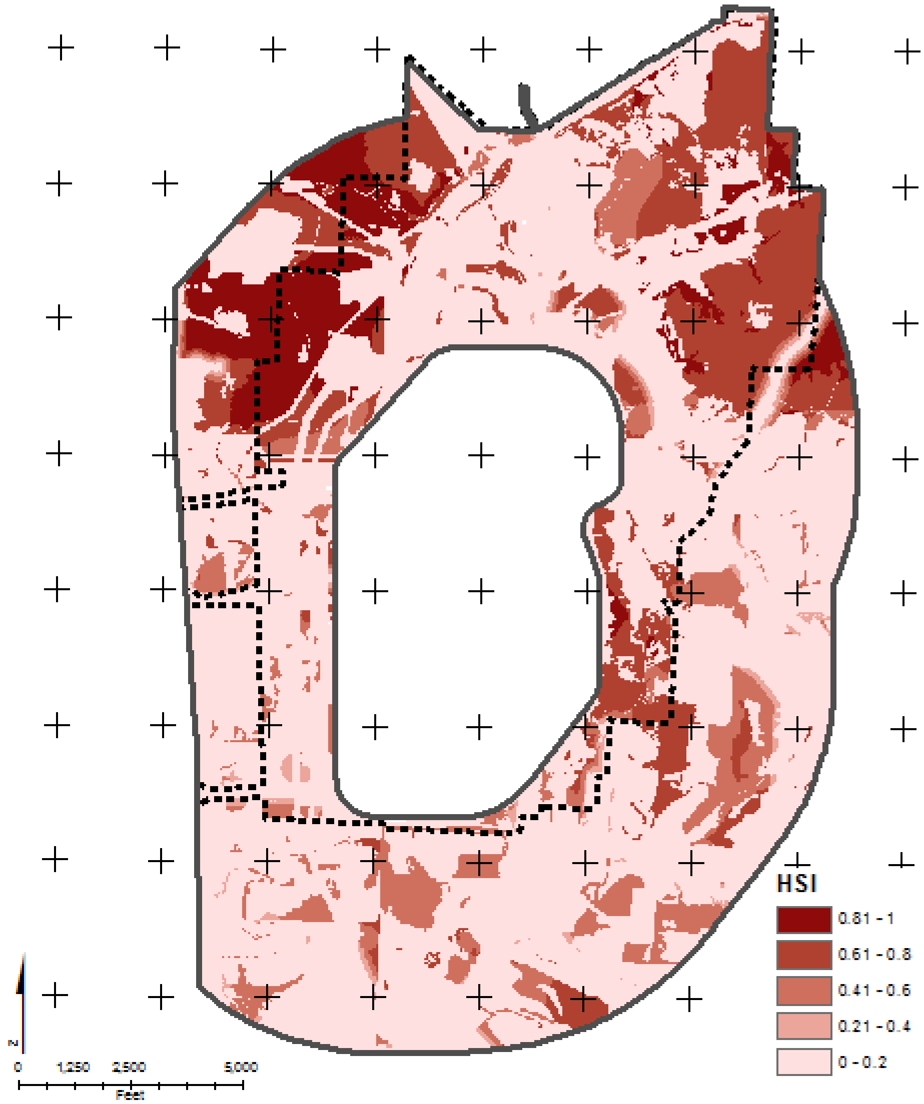

Figure 4.9 Timber Rattlesnake HSI, Darker Shading Denotes Higher Suitability

4.4 Recommendations for Future Analysis

The HSI models presented here are an example of the potential utility of the data provided by this study along with widely-available remote-sensed data for the development of high quality habitat assessments to increase the confidence of project planning and implementation decisions.

Beyond the current data collection and analysis, a wildlife management plan could be developed for the PORTS site using not only the data collected during the current project, but also through engagement of stakeholders to develop goals of wildlife management. To do this, further data collection would focus on the key stakeholders of the PORTS site, including the Department of Energy, community members and government agencies. The guidance from stakeholders will lead to further data collection and data anlaysis, like that shown here, to guide the long term wildlife management of the PORTS site. The goals of a wildlife management plan, as dictated by stakeholder, would lead to strategies for management of key species or key habitats in the future development of PORTS.

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Appendix A Habitat Map

Appendix B Summary of Public Involvement

Summary of public involvement

1. Presentation of first year‟s findings to the full SSAB Board by Rob Wiley and Bob Eichenberg, January 5, 2012. Comprehensive overview of accomplishments and work plan for 2012.
2. Habitat Task Tour conducted on March 22, 2012. This was conducted at the request of the SSAB to learn more about the Task and get input from Rob Wiley and the field crew. SSAB members in attendance were Brian Huber and Martha Cosby. Mr. Huber was particularly interested in future uses of the site and noted that he thinks that there is enough land to serve a variety of uses and that habitat protection and restoration should be possible on a lot of the property. He was very interested in the small and old woods on the southwest corner of the reservation and also how habitat will be affected in areas around the proposed OSDC.
3. Mailings to neighbors
    a. Autumn 2011 – Mailing to neighbors explaining the task, PORTSfuture (and how to participate with the future use survey), and stating that some may be asked to provide Right-of-entry (R-O-E).
    b. Spring 2012 – Phone contacts with selected neighbors for which we wanted R-O-E. Eventually sent out a targeted mailing to those who had phone numbers and expressed an interest but never followed through and to those who did not have a phone number.
    c. I had a number of conversations with neighbors who were all interested in our Task and wanted to see the results whenever they are available. There is quite a variety of owner categories: live on or off site, hunt, farm, etc. Everyone expressed an interest in wildlife even if just as passive observers.
4. Interview with Gary
    a. Van Meter property-Bill Shepherd, Caretaker
        i. DOE "pretty good neighbor".
        ii. Liked intact DOE habitat next door.
        iii. Repeat hunters come back to area due to big buck and turkey.
        iv. Appreciates stream and riparian quality (fish and macroinvertebrates).
        v. Recognized previous DOE contaminants-hot water release in streams that impacted fish, killing some.
    b. OVEC
        i. Manager observes wildlife from office. Enjoys turkey, deer, and song birds.
    c. Geoff Sea
        i. Field team discussed potential for more diversity but won‟t happen as long as horse grazing continues in some of the areas. Heard Bobwhite Quail on property.
    d. Cuckler
        i. Hunt on property, selectively logged recently.
    e. Cisco
        i. Hunt on property and manage for wildlife with upper fields in food plots.

Appendix C List of Plant Species

LIST OF VASCULAR PLANT SPECIES FOUND WITHIN THE DOE PORTS STUDY AREA DURING THE 2011 AND 2012 GROWING SEASONS

									Importance Value by Vegetated Habitat Type												
Field Code	*Taxon*	Common Name	Family	NATIVITY	WETLAND INDEX	C of C	FORM	Special Status	BLHF	Mature Oak-Hickory Forest	Mixed Mesic Forest	Mowed Maintained	Native Pine	Oldfield - Successional	Palustrine Emergent Wetland	Palustrine Forested Wetland	Palustrine Shrub-Scrub Wetland	Planted Pine	Ruderal Successional	Successional Forest	Successional Scrub
ACVI	*Acalypha virginica*	Virginia Threeseed Mercury	Euphorbiaceae	4	5	0	forb														
ACNE2	*Acer negundo*	Boxelder	Aceraceae	5	3	3	tree		2.44		0.65			2.07	4.55	10.7	6.23			0.78	
ACRU	*Acer rubrum*	Red Maple	Aceraceae	5	3	2	tree		6.26	5.08	4.89		10.4	63.2	9.7	12.4	15.6	5.47	9.9	9.46	9.81
ACSA2	*Acer saccharinum*	Silver Maple	Aceraceae	5	2	3	tree		8.13							21.3					
ACSA3	*Acer saccharum*	Sugar Maple	Aceraceae	5	5	5	tree		30.1	19.5	47.2		10.7			3.84	1.56			39.4	
ACMI2	*Achillea millefolium*	Common Yarrow	Asteraceae	4	4	1	forb														
ACAM	*Acorus americanus*	American Sweetflag	Acoraceae	5	1	6	forb	PT													
ACPA	*Actaea pachypoda*	White Baneberry	Ranunuculaceae	5	5	7	forb														
ACRA7	*Actaea racemosa*	Black Cohosh	Ranunuculaceae	5	4	7	forb														
ADPE	*Adiantum pedatum*	Northern Maidenhair Fern	Pteridaceae	5	3	6	fern														
AEGL	*Aesculus glabra*	Ohio Buckeye	Hippocastanacea	5	4	6	tree		0.98	0.46	0.63										
AGLI2	*Agalinis linifolia*	Flaxleaf False foxglove	Scrophulariaceae	NA	3	NA	forb														
AGPU5	*Agalinis purpurea*	Purple False Foxglove	Scrophulariaceae	5	2	6	forb														
AGTE3	*Agalinis tenuifolia*	Slenderleaf False Foxglove	Scrophulariaceae	5	3	4	forb														
AGNE2	*Agastache nepetoides*	Yellow Giant Hyssop	Lamiaceae	4	4	4	forb														
AGSC	*Agastache scrophulariifolia*	Purple Giant Hyssop	Lamiaceae	4	5	4	forb														
AGAL5	*Ageratina altissima*	White Snakeroot	Asteraceae	4	5	3	forb														

LIST OF VASCULAR PLANT SPECIES FOUND WITHIN THE DOE PORTS STUDY AREA DURING THE 2011 AND 2012 GROWING SEASONS

									Importance Value by Vegetated Habitat Type												
Field Code	*Taxon*	Common Name	Family	NATIVITY	WETLAND INDEX	C of C	FORM	Special Status	BLHF	Mature Oak-Hickory Forest	Mixed Mesic Forest	Mowed Maintained	Native Pine	Oldfield - Successional	Palustrine Emergent Wetland	Palustrine Forested Wetland	Palustrine Shrub-Scrub Wetland	Planted Pine	Ruderal Successional	Successional Forest	Successional Scrub
AGGR2	*Agrimonia gryposepala*	Tall Hairy Agrimony	Rosaceae	4	4	3	forb														
AGPA6	*Agrimonia parviflora*	Harvestlice	Rosaceae	4	3	2	forb														
AGRO3	*Agrimonia rostellata*	Beaked Agrimony	Rosaceae	4	4	5	forb														
AGST	*Agrimonia striata*	Woodland Agrimony	Rosaceae	4	5	7	forb														
AGGI2	*Agrostis gigantea*	Redtop-grass	Poaceae	3	2	0	grass														
AGHY	*Agrostis hyemalis*	Winter Bentgrass	Poaceae	5	3	3	grass														
AGPE	*Agrostis perennans*	Autumn Bentgrass	Poaceae	5	4	4	grass														
AIAL	*Ailanthus altissima*	Tree-of-Heaven	Simaroubaceae	1	5	0	tree	I													
ALSU	*Alisma subcordatum*	American Water Plantain	Alismataceae	5	1	2	forb														
ALPE4	*Alliaria petiolata*	Garlic Mustard	Brassicaceae	1	5	0	forb	I													
ALBU2	*Allium burdickii*	Narrowleaf Wild Leek	Liliaceae	5	4	8	forb														
ALCA3	*Allium canadense*	Meadow Garlic	Liliaceae	4	4	2	forb														
ALTR3	*Allium tricoccum*	Ramp	Liliaceae	5	4	5	forb														
ALVI	*Allium vineale*	Wild Garlic	Liliaceae	1	5	0	forb														
ALSE2	*Alnus serrulata*	Hazel Alder	Betulaceae	5	1	6	shru														
ALPR3	*Alopecurus pratensis*	Meadow Foxtail	Poaceae	1	2	0	grass														
AMAR2	*Ambrosia artemisiifolia*	Annual Ragweed	Asteraceae	4	4	0	forb			0.51											
AMTR	*Ambrosia trifida*	Great Ragweed	Asteraceae	4	3	0	forb														
AMAR3	*Amelanchier arborea*	Eastern Serviceberry	Rosaceae	5	3	5	tree			6.96	0.46		5.22			0.69					
AMFR	*Amorpha fruticosa*	False Indigo Bush	Fabaceae	5	2	3	forb														

LIST OF VASCULAR PLANT SPECIES FOUND WITHIN THE DOE PORTS STUDY AREA DURING THE 2011 AND 2012 GROWING SEASONS

									Importance Value by Vegetated Habitat Type												
Field Code	*Taxon*	Common Name	Family	NATIVITY	WETLAND INDEX	C of C	FORM	Special Status	BLHF	Mature Oak-Hickory Forest	Mixed Mesic Forest	Mowed Maintained	Native Pine	Oldfield - Successional	Palustrine Emergent Wetland	Palustrine Forested Wetland	Palustrine Shrub-Scrub Wetland	Planted Pine	Ruderal Successional	Successional Forest	Successional Scrub
AMCO2	*Ampelopsis cordata*	Heartleaf Peppervine	Vitaceae	5	3	7	vine		0.62							0.95					
AMBR2	*Amphicarpaea bracteata*	American Hogpeanut	Fabaceae	5	3	4	forb									0.67					
ANVI2	*Andropogon virginicus*	Broomsedge Bluestem	Poaceae	5	4	3	grass														
ANNE	*Antennaria neglecta*	Field Pussytoes	Asteraceae	5	5	1	forb														
ANPL	*Antennaria plantaginifolia*	Women's Tobacco	Asteraceae	5	5	1	forb														
ANSO	*Antennaria solitaria*	Singlehead Pussytoes	Asteraceae	5	5	3	forb														
APAM	*Apios americana*	Groundnut	Fabaceae	5	2	3	forb														
APHY	*Aplectrum hyemale*	Puttyroot	Orchidaceae	5	3	7	forb														
APCA	*Apocynum cannabinum*	Indianhemp	Apocynaceae	4	4	1	forb														
ARCA	*Arabis canadensis*	Sicklepod	Brassicaceae	4	5	5	forb														
ARMI2	*Arctium minus*	Lesser Burdock	Asteraceae	1	5	0	forb														
ARDR3	*Arisaema dracontium*	Green Dragon	Araceae	5	2	5	forb														
ARTR	*Arisaema triphyllum*	Jack in the Pulpit	Araceae	5	2	3	forb														
ARDI4	*Aristida dichotoma*	Churchmouse Treeawn	Poaceae	5	5	1	grass														
ARSE3	*Aristolochia serpentaria*	Virginia Snakeroot	Aristolochiaceae	5	5	7	forb														
ARTO3	*Aristolochia tomentosa*	Wooly Dutchman's Pipe	Aristolochiaceae	4	3	0	vine									0.78					
ARAT	*Arnoglossum atriplicifolium*	Pale Indian Plantain	Asteraceae	5	5	6	forb														
ARAB3	*Artemisia absinthium*	Wormwood	Asteraceae	2	5	0	forb														
ARGI	*Arundinaria gigantea*	Giant Cane	Poaceae	5	2	7	grass														
ASHI	*Asclepias hirtella*	Green Milkweed	Asclepiadaceae	5	5	8	forb														

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ASIN	*Asclepias incarnata*	Swamp Milkweed	Asclepiadaceae	5	1	4	forb														
ASPU2	*Asclepias purpurascens*	Purple Milkweed	Asclepiadaceae	5	4	7	forb														
ASQU	*Asclepias quadrifolia*	Fourleaf Milkweed	Asclepiadaceae	5	5	6	forb														
ASSY	*Asclepias syriaca*	Common Milkweed	Asclepiadaceae	4	5	1	forb														
ASTU	*Asclepias tuberosa*	Butterfly Milkweed	Asclepiadaceae	5	5	4	forb														
ASTR	*Asimina triloba*	Pawpaw	Annonaceae	5	4	6	tree		16.9	7.14	14.9		1.26			5.14				8.35	
ASMO2	*Asplenium montanum*	Mountain Spleenwort	Aspleniaceae	5	5	7	fern														
ASPL	*Asplenium platyneuron*	Ebony Spleenwort	Aspleniaceae	5	4	3	fern														
AULA	*Aureolaria laevigata*	Entireleaf Yellow False	Scrophulariaceae	5	5	8	forb														
AVSA	*Avena sativa*	Common Oat	Poaceae	3	5	0	grass														
BAVI3	*Bartonia virginica*	Yellow Screwstem	Gentianaceae	5	2	6	forb														
BETH	*Berberis thunbergii*	Japenese Barberry	Berberidaceae	1	4	0	shru	I	1.38		1.12									2.13	
BENI	*Betula nigra*	River Birch	Betulaceae	5	2	9	tree		5.37							13.7	2.08			5.6	
BIAR	*Bidens aristosa*	Tick-seed Sunflower	Asteraceae	5	2	4	forb														
BIBI7	*Bidens bipinnata*	Spanish Needles	Asteraceae	4	4	2	forb														
BICE	*Bidens cernua*	Nodding Tick-trefil	Asteraceae	5	1	3	forb														
BICO5	*Bidens connata*	Purplestem Beggarstick	Asteraceae	5	2	3	forb														
BICO	*Bidens coronata*	Tickseed Sunflower	Asteraceae	5	1	3	forb														
BIFR	*Bidens frondosa*	Devil's Beggartick	Asteraceae	5	2	2	forb														
BITR	*Bidens tripartita*	Threelobe Beggarsticks	Asteraceae	5	1	3	forb														

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BOCY	*Boehmeria cylindrica*	False Nettle	Urticaceae	5	2	4	forb														
BOBI	*Botrychium biternatum*	Sparselobe grapefern	Ophioglossaceae	5	3	4	fern	E													
BODI2	*Botrychium dissectum*	Cutleaf Grapefern	Ophioglossaceae	5	3	3	fern														
BOVI	*Botrychium virginianum*	Rattlesnake Fern	Ophioglossaceae	5	4	4	fern														
BOCU	*Bouteloua curtipendula*	Sideoats Grama	Poaceae	5	5	8	grass														
BRER2	*Brachyelytrum erectum*	Bearded Shorthusk	Poaceae	5	5	5	grass														
BRIN2	*Bromus inermis*	Smooth Brome	Poaceae	1	5	0	grass	I													
CAPOI	*Calamagrostis porteri*	Porter's Reedgrass	Poaceae	5	5	8	grass	T													
CASC5	*Camassia scilloides*	Wild Hyacinth	Liliaceae	5	3	6	forb														
CARA2	*Campsis radicans*	Trumpet Creeper	Bignoniaceae	4	3	1	vine		1.23	0.28	1.34			2.22		1.81	3.31				
CAAN1	*Cardamine angustata*	Slender Toothwort	Brassicaceae	5	4	7	forb														
CACO26	*Cardamine concatenata*	Cutleaf Toothwort	Brassicaceae	5	4	3	forb														
CAHI3	*Cardamine hirsuta*	Hairy Bittercress	Brassicaceae	1	4	0	forb														
CARO3	*Cardamine rotundifolia*	American Bittercress	Brassicaceae	5	1	9	forb														
CAAL11	*Carex albursina*	White Bear Sedge	Cyperaceae	5	5	6	sedg				0.29										
CAAM8	*Carex amphibola*	Eastern Narrowleaf Sedge	Cyperaceae	5	3	5	sedg														
CAAN6	*Carex annectens*	Yellowfruit Sedge	Cyperaceae	5	2	3	sedg														
CABE2	*Carex bebbii*	Bebb's Sedge	Cyperaceae	5	1	7	sedg														
CABL	*Carex blanda*	Eastern Woodland Sedge	Cyperaceae	5	3	1	sedg														
CABU6	*Carex buxbaumii*	Buxbaum's Sedge	Cyperaceae	5	1	8	sedg														

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CACA15	*Carex caroliniana*	Carolina Sedge	Cyperaceae	5	4	4	sedg														
CACO22	*Carex corrugata*	Prune-fruit Sedge	Cyperaceae	NA	3	NA	sedg														
CACR7	*Carex cristatella*	Crested Sedge	Cyperaceae	5	2	3	sedg														
CAFR3	*Carex frankii*	Frank's Sedge	Cyperaceae	5	1	2	sedg														
CAGL6	*Carex glaucodea*	Blue Sedge	Cyperaceae	5	3	5	sedg														
CAGR8	*Carex gracilescens*	Slender Wood Sedge	Cyperaceae	5	5	3	sedg														
CAGR3	*Carex granularis*	Limestone Meadow Sedge	Cyperaceae	5	2	3	sedg														
CAGR24	*Carex grisea*	Inflated Narrow-leaf Sedge	Cyperaceae	5	3	4	sedg														
CAHI6	*Carex hirsutella*	Fuzzy wuzzy Sedge	Cyperaceae	5	4	2	sedg														
CAHY4	*Carex hystricina*	Bottlebrush Sedge	Cyperaceae	5	1	5	sedg														
CAIN12	*Carex intumescens*	Greater Bladder Sedge	Cyperaceae	5	2	5	sedg														
CAJA2	*Carex jamesii*	James' Sedge	Cyperaceae	5	5	6	sedg														
CALA16	*Carex lacusris*	Lake Sedge	Cyperaceae	5	1	5	sedg														
CALA14	*Carex laevivaginata*	Smoothsheath Sedge	Cyperaceae	5	1	6	sedg														
CALA18	*Carex laxiculmis*	Spreading Sedge	Cyperaceae	5	5	3	sedg														
CALA19	*Carex laxiflora*	Two-edged Wood Sedge	Cyperaceae	5	4	3	sedg														
CALU5	*Carex lurida*	Shallow Sedge	Cyperaceae	5	1	3	sedg														
CANO	*Carex normalis*	Greater Straw Sedge	Cyperaceae	5	4	4	sedg														
CAOL2	*Carex oligocarpa*	Few-fruited Sedge	Cyperaceae	5	5	6	sedg														
CAPE6	*Carex pensylvanica*	Pennsylvania Sedge	Cyperaceae	5	5	3	sedg														

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CARO22	*Carex rosea*	Roseate Sedge	Cyperaceae	5	5	3	sedg														
CASC11	*Carex scoparia*	Broom Sedge	Cyperaceae	5	2	3	sedg														
CASW	*Carex swanii*	Swan's Sedge	Cyperaceae	5	4	4	sedg														
CATO4	*Carex torta*	Twisted Sedge	Cyperaceae	5	2	8	sedg														
CATR7	*Carex tribuloides*	blunt broom sedge	Cyperaceae	5	2	4	sedg														
CATY	*Carex typhina*	Cattail Sedge	Cyperaceae	5	2	5	sedg														
CAVU2	*Carex vulpinoidea*	Fox Sedge	Cyperaceae	5	1	1	sedg														
CAWI2	*Carex willdenowii*	Willdenow's Sedge	Cyperaceae	5	5	6	sedg														
CACA18	*Carpinus caroliniana*	American Hornbeam	Betulaceae	5	3	5	tree		1.63	0.84	0.79					2.17	2.01			1.41	
CAAL27	*Carya alba*	Mockernut Hickory	Juglandaceae	5	5	6	tree		0.49	8.76	1.12		8.87	3.01							5.3
CACO15	*Carya cordiformis*	Bitternut Hickory	Juglandaceae	5	4	5	tree			1.69	5.93										
CAGL8	*Carya glabra*	Pignut Hickory	Juglandaceae	5	5	5	tree		1.71	12.0	5.04		10.5	4.74						3.4	5.49
CAOV3	*Carya ovalis*	Red Hickory	Juglandaceae	5	5	5	tree				1.25		2.15								
CAOV2	*Carya ovata*	Shagbark Hickory	Juglandaceae	5	5	6	tree		5.69	14.9	9.49		2.27	4.17		2.58				2.26	
CASP8	*Catalpa speciosa*	Northern Catalpa	Bignoniaceae	4	3	0	tree												7.87		
CEOR7	*Celastrus orbiculatus*	Oriental bittersweet	Celastraceae	1	4	0	vine	I												0.87	
CESC	*Celastrus scandens*	American Bittersweet	Celastraceae	5	5	2	vine										1.76				
CEOC	*Celtis occidentalis*	Common Hackberry	Ulmaceae	5	4	4	tree		1.9		1.77					1.16					
CECA4	*Cercis canadensis*	Eastern Redbud	Fabaceae	5	5	3	tree		1.55		1.45					0.81				1.09	
CHFA2	*Chamaecrista fasciculata*	Partridge Pea	Fabaceae	5	4	3	forb														

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CHMA1	*Chamaesyce maculata*	Prostrate Spurge	Euphorbiaceae	4	5	0	forb														
CHNU9	*Chamaesyce nutans*	Spotted Spurge	Euphorbiaceae	4	5	0	forb														
CHSI2	*Chenopodium simplex*	Mapleleaf Goosefoot	Chenopodiaceae	4	5	1	forb														
CIMA2	*Cicuta maculata*	Spotted Water Hemlock	Apiaceae	5	1	3	forb														
CIAR2	*Cinna arundinacea*	Sweet Woodreed	Poaceae	5	2	4	grass														
CILU	*Circaea lutetiana*	Enchanter's Nightshade	Onagraceae	5	4	3	forb														
CIAL2	*Cirsium altissimum*	Tall Thistle	Asteraceae	5	5	4	forb														
CIDI	*Cirsium discolor*	Field Thistle	Asteraceae	5	5	4	forb														
CLVI3	*Claytonia virginica*	Virginia Springbeauty	Portulacaceae	5	4	2	forb														
CLVI5	*Clematis virginiana*	Devil's Darning Needles	Ranunuculaceae	5	3	3	forb										3.22				
COCA4	*Collinsonia canadensis*	Richweed	Lamiaceae	5	3	5	forb														
COCO3	*Commelina communis*	Asiatic Dayflower	Commelinaceae	1	3	0	forb														
COMA2	*Conium maculatum*	Poison Hemlock	Apiaceae	1	2	0	forb	I													
COCO1	*Conoclinium coelestinum*	Blue Mist-flower	Asteraceae	5	3	3	forb														
COAM	*Conopholis americana*	American Cancer-root	Orobanchaceae	5	5	7	forb														
COCA5	*Conyza canadensis*	Canadian Horseweed	Asteraceae	4	5	0	forb	AI													
COLA5	*Coreopsis lanceolata*	Lanceleaf Tickseed	Asteraceae	5	4	0	forb														
COAM2	*Cornus amomum*	Silky Dogwood	Cornaceae	5	2	2	shru				0.91					0.74					
CODR	*Cornus drummondii*	Roughleaf Dogwood	Cornaceae	5	3	3	shru									0.68	3.12				
COFL2	*Cornus florida*	Flowering Dogwood	Cornaceae	5	5	5	tree		5.26	5.43	5.45	21.09	6.13	6.73	4.79	3.15	6.31	8.11	10.9	3.3	8.35

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CORA6	*Cornus racemosa*	Gray Dogwood	Cornaceae	5	3	1	shru														
COSE16	*Cornus sericea*	Redosier Dogwood	Cornaceae	5	2	3	shru				0.22				3.87						
COFL3	*Corydalis flavula*	Yellow Fumewort	Fumariaceae	5	4	4	forb														
COAM3	*Corylus americana*	American Hazelnut	Betulaceae	5	5	4	shru														
CRCR2	*Crataegus crus-galli*	Cockspur Hawthorn	Rosaceae	5	4	3	tree										2.89			0.78	
CRMO3	*Crataegus monogyna*	Oneseed Hawthorn	Rosaceae	1	5	0	tree														
CRPR2	*Crataegus pruinosa*	Waxyfruit Hawthorn	Rosaceae	5	5	2	tree										1.78				
CRATA	*Crataegus sp.*	Hawthorn	Rosaceae	5	3	1	tree		0.5	0.86			1.7								
CRSU5	*Crataegus succulenta*	Fleshy Hawthorn	Rosaceae	5	5	4	tree										1.77				
CRPE10	*Cruciata pedemontana*	Piedmont Begstraw	Rubiaceae	1	5	0	forb														
CUOR	*Cunilla origanoides*	Common Dittany	Lamiaceae	5	5	6	forb														
CYVI	*Cynoglossum virginianum*	Wild Comfrey	Boraginaceae	5	5	5	forb														
CYST	*Cyperus strigosus*	Strawcolored Flatsedge	Cyperaceae	4	2	1	sedg														
CYPR4	*Cystopteris protrusa*	Lowland Bladderfern	Dryopteridaceae	5	5	5	fern														
CYTE7	*Cystopteris tenuis*	Upland Brittle Bladderfern	Dryopteridaceae	5	5	5	fern														
DAGL	*Dactylis glomerata*	Orchardgrass	Poaceae	3	4	0	grass														
DACO	*Danthonia compressa*	Flattened Oatgrass	Poaceae	5	5	4	grass														
DASP2	*Danthonia spicata*	Poverty Oargrass	Poaceae	5	5	4	grass														
DACA6	*Daucus carota*	Quenn Anne's Lace	Apiaceae	1	5	0	forb	I													
DETR	*Delphinium tricorne*	Spring Larkspur	Ranunuculaceae	5	5	4	forb														

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DEPU2	*Dennstaedtia puntilobula*	Eastern Hayscented Fern	Dennstaedtiaceae	5	5	6	fern														
DEAC4	*Deparia acrostichoides*	Silver False Spleenwort	Dryopteridaceae	5	3	6	fern														
DECA7	*Desmodium canadense*	Showy Ticktrefoil	Fabaceae	5	3	4	forb														
DEPA6	*Desmodium paniculatum*	Panicledleaf Ticktrefoil	Fabaceae	5	5	3	forb														
DEST2	*Desmodium strictum*	Pine Barren Ticktrefoil	Fabaceae	NA	4	NA	forb														
DIAR	*Dianthus armeria*	Deptford Pink	Caryophyllaceae	3	5	0	forb														
DICA	*Dicentra canadensis*	Squirrel Corn	Fumariaceae	5	5	6	forb														
DICU	*Dicentra cucullaria*	Dutchman's Breeches	Fumariaceae	5	5	6	forb														
DIAC2	*Dichanthelium acuminatum*	tapered rosette grass	Poaceae	5	3	2	grass														
DICL	*Dichanthelium clandestinum*	Deertongue	Poaceae	5	3	2	grass														
DIDI6	*Dichanthelium dichotomum*	Small-seeded Panic-grass	Poaceae	5	3	4	grass														
DILA8	*Dichanthelium latifolium*	Broadleaf Rosette Grass	Poaceae	5	5	4	grass														
DISC2	*Dichanthelium scabriusculum*	Wolly Rosette Grass	Poaceae	5	1	3	grass														
DILO	*Diervilla lonicera*	Northern Bush Honeysuckle	Caprifoliaceae	5	5	7	shru														
DIIS	*Digitaria ischaemum*	Smooth Crabgrass	Poaceae	1	5	0	grass	AI													
DITE2	*Diodia teres*	Rough Buttonweed	Rubiaceae	5	5	3	forb														
DIVI4	*Dioscorea villosa*	Wild Yam	Dioscoreaceae	5	3	4	vine		0.49												
DIVI5	*Diospyros virginiana*	Common Persimmon	Ebenaceae	5	3	4	tree			1.07	1.88	127.3	1.06	8.23	16.4			7.42	6.47	2.09	14.7
DIFU2	*Dipsacus fullonum*	Teasel	Dipsacaeae	1	5	0	forb	I													
DOIN2	*Doellingeria infirma*	Cornel-leaf Whitetop	Asteraceae	5	5	8	forb														

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ECCR	*Echinochloa crus-galli*	Barnyard-grass	Poaceae	1	4	0	grass	AI													
ELAN	*Elaeagnus angustifolia*	Russian Olive	Eleaegnaceae	1	4	0	tree	I	2.34		1.24					5.19	4.06	12.3			
ELAC	*Eleocharis acicularis*	Least Spikerush	Cyperaceae	5	1	5	sedg														
ELOB2	*Eleocharis obtusa*	Blunt Spikerush	Cyperaceae	5	1	1	sedg														
ELQU	*Eleocharis quadrangulata*	Four-angled Spikerush	Cyperaceae	5	1	4	sedg														
ELCA3	*Elephantopus carolinianus*	Carolina Elenphants Foot	Asteraceae	5	4	4	forb														
ELCA4	*Elymus canadensis*	Canada Wildrye	Poaceae	5	4	6	grass														
ELHY	*Elymus hystrix*	Eastern Bottlebrush Grass	Poaceae	5	5	4	grass														
ELVI	*Elymus villosus*	Hairy Wildrye	Poaceae	5	5	4	grass														
ENBI	*Enemion biternatum*	Eastern False Rue Anemone	Ranunuculaceae	5	5	7	forb														
EPVI2	*Epifagus virginiana*	Beechdrops	Orobanchaceae	5	5	10	forb														
EPCO	*Epilobium coloratum*	Purpleleaf Willowherb	Onagraceae	5	1	1	forb														
EQAR	*Equisetum arvense*	Field Horsetail	Equisetaceae	4	3	0	fern														
EQHY	*Equisetum hyemale*	Scouring Rush	Equisetaceae	5	2	2	fern														
ERFR	*Eragrostis frankii*	Sandbar Lovegrass	Poaceae	5	2	3	grass														
ERHI2	*Erichtites hieraciifolia*	American burnweed	Asteraceae	5	4	2	forb														
ERAN	*Erigeron annuus*	Eastern Daisy Fleabane	Asteraceae	4	4	0	forb														
ERST3	*Erigeron strigosus*	Praiarie Fleabane	Asteraceae	5	4	1	forb														
ERAL9	*Erythronium albidum*	White Troutlily	Liliaceae	5	4	5	forb														
ERAM5	*Erythronium americanum*	Yellow Troutlily	Liliaceae	5	5	4	forb														

LIST OF VASCULAR PLANT SPECIES FOUND WITHIN THE DOE PORTS STUDY AREA DURING THE 2011 AND 2012 GROWING SEASONS

									Importance Value by Vegetated Habitat Type												
Field Code	*Taxon*	Common Name	Family	NATIVITY	WETLAND INDEX	C of C	FORM	Special Status	BLHF	Mature Oak-Hickory Forest	Mixed Mesic Forest	Mowed Maintained	Native Pine	Oldfield - Successional	Palustrine Emergent Wetland	Palustrine Forested Wetland	Palustrine Shrub-Scrub Wetland	Planted Pine	Ruderal Successional	Successional Forest	Successional Scrub
EUAL13	*Euonymus alatus*	Burningbush	Celastraceae	1	5	0	shru	I			0.22										
EUAM9	*Euonymus americanus*	Bursting-heart	Celastraceae	5	3	6	shru														
EUAT5	*Euonymus atropurpureus*	Eastern Wahoo	Celastraceae	5	4	3	shru									0.68	1.93				
EUMA1	*Eupatoriadelphus maculatus*	Spotted Trumpetweed	Asteraceae	5	2	6	forb														
EUAL2	*Eupatorium album*	White Thoroughwort	Asteraceae	5	5	8	forb	T													
EUPE3	*Eupatorium perfoliatum*	Common Boneset	Asteraceae	5	2	3	forb														
EUPU10	*Eupatorium purpureum*	Purple Joepye-weed	Asteraceae	5	3	5	forb														
EURO4	*Eupatorium rotundifolium*	Roundleaf Thoroughwort	Asteraceae	5	3	6	forb														
EUSE2	*Eupatorium serotinum*	Late-flowering Thoroughwort	Asteraceae	5	3	2	forb														
EUCO1	*Euphorbia corollata*	Flowering Spurge	Euphorbiaceae	5	5	4	forb														
EUSP	*Euphorbia spathulata*	Blunt-leaved Spurge	Euphorbiaceae	5	5	4	forb														
EUDI16	*Eurybia divaricata*	White Wood Aster	Asteraceae	5	5	5	forb														
EUGR5	*Euthamia graminifolia*	Flat-top Goldenrod	Asteraceae	5	3	2	forb														
FAGR	*Fagus grandifolia*	American Beech	Fagaceae	5	4	7	tree		15.9	7.59	5.31									6.08	
FERU2	*Festuca rubra*	Red Fescue	Poaceae	1	4	0	grass	AI													
FESU3	*Festuca subverticillata*	Nodding Fescue	Poaceae	5	4	5	grass														
FRVE	*Fragaria vesca*	Woodland Strawberry	Rosaceae	5	5	3	forb														
FRVI	*Fragaria virginiana*	Virginia Strawberry	Rosaceae	5	4	1	forb														
FRCA2	*Frasera caroliniensis*	Amercian Columbo	Gentianaceae	5	5	7	forb														
FRAM2	*Fraxinus americana*	White Ash	Oleaceae	5	4	6	tree			2.2			1.18			0.72					

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FRNI	*Fraxinus nigra*	Black Ash	Oleaceae	5	2	7	tree			0.82	1.23				4.16		1.62				
FRPE	*Fraxinus pennsylvanica*	Green Ash	Oleaceae	5	2	3	tree		11.3	5.44	8.56		13.9	5.66	31.0	13.1	2.16	12.1	5.55	9.84	8.91
GASP5	*Galearis spectabilis*	Showy Orchis	Orchidaceae	5	5	7	forb														
GAAP2	*Galium aparine*	Stickywilly	Rubiaceae	4	4	0	forb														
GAAS2	*Galium asprellum*	Rough Bedstraw	Rubiaceae	5	1	4	forb														
GABO2	*Galium boreale*	Northern Bedstraw	Rubiaceae	5	4	8	forb														
GACI2	*Galium circaezans*	Licorice Bedstraw	Rubiaceae	5	5	4	forb														
GACO3	*Galium concinnum*	Shining Bedstraw	Rubiaceae	5	5	5	forb														
GAPA3	*Galium palustre*	Common Marsh Bedstraw	Rubiaceae	5	1	9	forb	E													
GATI	*Galium tinctorium*	Marsh Bedstraw	Rubiaceae	5	1	4	forb														
GATR3	*Galium triflorum*	Fragrant Bedstraw	Rubiaceae	5	4	4	forb														
GAFR2	*Gaylussacia frondosa*	Blue Huckleberry	Ericaceae	NA	3	NA	shru														
GECA5	*Geranium carolinianum*	Carolina Geranium	Geraniaceae	5	5	3	forb														
GECA7	*Geum canadense*	White Avens	Rosaceae	5	4	2	forb														
GELA	*Geum laciniatum*	Rough Avens	Rosaceae	5	3	2	forb														
GIST5	*Gillenia stipulata*	American Ipecac	Rosaceae	5	5	6	forb														
GLHE2	*Glechoma hederacea*	Ground Ivy	Lamiaceae	1	4	0	forb														
GLTR	*Gleditsia triacanthos*	Honeylocust	Fabaceae	5	3	4	tree				2.15			8.82		1.35	5.92	7.17	50.3	4.64	
GLME2	*Glyceria melicaria*	Melic Mannagrass	Poaceae	5	1	7	grass		0.55												
GLST	*Glyceria striata*	Fowl Mannagrass	Poaceae	5	1	2	grass														

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GOPU	*Goodyear pubescens*	Downy Rattlesnake Plantain	Orchidaceae	5	5	6	forb														
HAVI2	*Hackelia virginiana*	Beggarsice	Boraginaceae	5	4	2	forb														
HEAU	*Helenium autumnale*	Common Sneezeweed	Asteraceae	5	2	4	forb														
HEDI2	*Helianthus divarcatus*	Woodland Sunflower	Asteraceae	5	5	4	forb														
HEGI	*Helianthus giganteus*	Swamp Sunflower	Asteraceae	5	2	6	forb														
HEMA3	*Hesperis matronalis*	Dames Rocket	Brassicaceae	1	5	0	forb	I													
HEAM6	*Heurhera americana*	American Alumroot	Saxifragaceae	5	5	4	forb														
HIGR3	*Hieracium gronovii*	Queendevil	Asteraceae	5	5	5	forb														
HIVE	*Hieracium venosum*	Rattlesnakeweed	Asteraceae	5	5	6	forb														
HOLA	*Holcus lanatus*	Common Velvetgrass	Poaceae	2	4	0	grass														
HOCA4	*Houstonia caerulea*	Bluets, Quaker Ladies	Rubiaceae	5	4	3	forb														
HOCA5	*Houstonia canadensis*	Canadian Summer Bluet	Rubiaceae	5	5	6	forb														
HULU	*Humulus lupulus*	Common Hop	Cannabaceae	4	4	2	vine				0.3						1.48				
HYAR	*Hydrangea arborescens*	Wild Hydrangea	Hydrangeaceae	5	4	7	shru														
HYCA	*Hydrastis canadensis*	Goldenseal	Ranunuculaceae	5	5	7	forb														
HYVI	*Hydrophyllum virginianum*	Eastern Waterleaf	Hydrophylleaceae	5	3	4	forb														
HYHY	*Hypericum hypericoides*	St. Andrews Cross	Clusiaceae	5	5	6	shru														
HYMA2	*Hypericum majus*	Large St. Johnswort	Clusiaceae	5	2	6	forb														
HYMU	*Hypericum muticum*	Dwarf St. Johnswort	Clusiaceae	5	2	3	forb														
HYPR	*Hypericum prolificum*	Shrubby St. Johnswort	Clusiaceae	5	4	3	shru		3.93	2.47	4.86		3.29	61.9	5.47	0.67	22.1	5.58	18.1	10.7	38.5

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HYPU	*Hypericum punctatum*	Spotted St. Johnswort	Clusiaceae	5	3	2	forb														
HYSP2	*Hypericum sphaerocarpum*	Roundseed St. JohnsWort	Clusiaceae	5	4	6	forb														
HYHI2	*Hypoxis hirsuta*	Yellow Stargrass	Liliaceae	5	3	6	forb														
IMCA	*Impatiens capensis*	Jewelweed	Balsaminaceae	5	2	2	forb														
IMPA	*Impatiens pallida*	Pale Touch-me-not	Balsaminaceae	5	2	3	forb														
IPLA	*Ipomoea lacunosa*	Whitestar	Convolvulaceae	5	2	4	forb														
IPPA	*Ipomoea pandurata*	Wild Potato Vine	Convolvulaceae	5	4	2	forb														
JUNI	*Juglans nigra*	Black Walnut	Juglandaceae	5	4	5	tree		11.7	0.46	5.97			6.34		17.5	12.9			3.02	
JUAC	*Juncus acuminatus*	Sharpfruited Rush	Juncaceae	5	1	4	forb														
JUBU	*Juncus bufonius*	Toad Rush	Juncaceae	5	2	2	forb														
JUDU2	*Juncus dudleyi*	Dudley's Rush	Juncaceae	5	2	3	forb														
JUEF	*Juncus effusus*	Common Rush	Juncaceae	5	2	1	forb														
JUSE	*Juncus secundus*	Lopsided Rush	Juncaceae	5	4	5	forb	PT													
JUTE	*Juncus tenuis*	Poverty Rush	Juncaceae	5	3	1	forb														
JUVI	*Juniperus virginiana*	Eastern Redcedar	Cupressaceae	5	4	3	tree		1.02	0.86	1.05		4.17	2.59	4.52	1.14			5.92	1.53	28.1
KRBI	*Krigia biflora*	TwoFlower Dwarfdandelion	Asteraceae	5	4	5	forb														
KRDA	*Krigia dandelion*	Potato Dwarfdandelion	Asteraceae	5	3	8	forb	T													
LAPU2	*Lamium purpureum*	Purple Deadnettle	Lamiaceae	1	5	0	forb														
LACA3	*Laportea canadensis*	Canadian Woodnettle	Urticaceae	5	2	5	forb														
LEOR	*Leersia oryzoides*	Rice-cutgrass	Poaceae	5	1	1	grass														

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LEVI2	*Leersia virginica*	Whitegrass	Poaceae	5	2	4	grass														
LECA5	*Lepidium campestre*	Field Pepperweed	Brassicaceae	1	5	0	forb	AI													
LECA8	*Lespedeza capitata*	Roundhead Lespedeza	Fabaceae	5	5	5	forb														
LECU	*Lespedeza cuneata*	Sericea Lespedeza	Fabaceae	1	5	0	forb														
LEHI2	*Lespedeza hirta*	Hairy Lespedeza	Fabaceae	5	5	5	forb														
LEPR	*Lespedeza procumbens*	Trailing Lespedeza	Fabaceae	5	5	5	forb														
LERE2	*Lespedeza repens*	Creeping Lespedeza	Fabaceae	5	5	6	forb														
LEVI6	*Lespedeza violacea*	Violet Lespedeza	Fabaceae	5	5	4	forb														
LEVI7	*Lespedeza virginica*	Slender Lespedeza	Fabaceae	5	5	3	forb														
LEVU	*Leucanthemum vulgare*	Oxeye Daisy	Asteraceae	1	5	0	forb	AI													
LIAS	*Liatris aspera*	Tall Blazing Star	Asteraceae	5	5	6	forb														
LIVU	*Ligustrum vulgare*	European privet	Oleaceae	1	4	0	shru	I	1.97	0.26	0.27					0.67				4.3	
LIBE3	*Lindera benzoin*	Northern Spicebush	Lauraceae	5	2	5	shru		17.5		5.27		3.41			6.91	2.73	5.58		5.46	
LIVI	*Linum virginianum*	Woodland Flax	Linaceae	5	4	4	forb														
LILI3	*Liparis liliifolia*	Brown Widelip Twayblade	Orchidaceae	5	5	5	forb														
LITU	*Liriodendron tulipifera*	Tuliptree	Magnoliaceae	5	4	6	tree		7.24		18.6		8.15			3.29	6.17			4.66	
LOCA2	*Lobelia cardinalis*	Cardinal Flower	Campanulaceae	5	2	5	forb														
LOIN	*Lobelia inflata*	Indian Tobacco	Campanulaceae	5	4	1	forb														
LOSI	*Lobelia siphilitica*	Great Blue Lobelia	Campanulaceae	5	2	3	forb														
LOSP	*Lobelia spicata*	Palespike Lobelia	Campanulaceae	5	3	5	forb														

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LOJA	*Lonicera japonica*	Japenese Honeysuckle	Caprifoliaceae	1	3	0	vine	I	5.2	2.08	4.97	52.1	1.47	4.25	5.98	15.7	14.8	16.1	5.28	12.3	11.9
LOMA6	*Lonicera maackii*	Bush/Amur Honeysuckle	Caprifoliaceae	1	5	0	shru	I	2.23	0.78	5.72		1.25			9.22		13.0		3.45	
LOCO6	*Lotus corniculatus*	Bird's-foot Trefoil	Fabaceae	1	5	0	forb														
LUAL2	*Ludwigia alternafolia*	Seedbox	Onagraceae	5	2	3	forb														
LUPA	*Ludwigia palustris*	Marsh Seedbox	Onagraceae	5	1	3	forb														
LUAC	*Luzula acuminata*	Hairy Woodrush	Juncaceae	5	3	6	forb														
LUBU	*Luzula bulbosa*	Bulbous Woodrush	Juncaceae	5	4	5	forb	T													
LYDE	*Lycopodium dendroideum*	Tree Groundpine	Lycopodiaceae	5	4	5	fern														
LYDI3	*Lycopodium digitatum*	Groundcedar	Lycopodiaceae	5	5	1	fern														
LYAM	*Lycopus americanus*	American Water Horehound	Lamiaceae	5	1	3	forb														
LYUN	*Lycopus uniflorus*	Northern Bugleweed	Lamiaceae	5	1	3	forb														
LYVI4	*Lycopus virginicus*	Virginia Water Horehound	Lamiaceae	5	1	3	forb														
LYCI	*Lysimachia ciliata*	Fringed Loosestrife	Primulaceae	5	2	4	forb														
LYLA	*Lysimachia lanceolata*	Lanceleaf Loosestrife	Primulaceae	5	3	6	forb														
LYNU	*Lysimachia nummularia*	Moneywort	Primulaceae	1	5	0	forb	I													
LYQU	*Lysimachia quadriflora*	Fourflower Yellow	Primulaceae	5	2	7	forb														
LYQU2	*Lysimachia quadrifolia*	Whorled Yellow Loosestrife	Primulaceae	5	5	5	forb														
MAPO	*Maclura pomifera*	Osage Orange	Moraceae	2	5	0	tree														
MARA7	*Maianthemum racemosum*	False Soloman's Seal	Liliaceae	5	5	4	forb														
MACO5	*Malus coronaria*	Sweet Crabapple	Rosaceae	5	5	3	tree				0.28							5.31			

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MEVI	*Medeola virginiana*	Indian Cucumber	Liliaceae	5	5	6	forb														
MELU	*Medicago lupulina*	Black Medic	Fabaceae	1	5	0	forb														
MENI	*Melica nitens*	Threeflower Melicgrass	Poaceae	5	5	8	grass														
MEOF	*Melilotus officinalis*	Yellow Sweetclover	Fabaceae	1	5	0	forb	I													
MECA3	*Menispermum canadense*	Canada Moonseed	Menispermaceae	5	4	5	vine		1.18		0.25					0.85					
MEPI	*Mentha piperita*	Peppermint	Lamiaceae	2	2	0	forb														
MIVI	*Microstegium vimineum*	Asian Microstegium	Poaceae	1	3	0	grass	I													
MIRI	*Mimulus ringens*	Allegheny Monkeyflower	Scrophulariaceae	5	1	4	forb														
MIRE	*Mitchella repens*	Partridgeberry	Rubiaceae	5	4	5	forb														
MIDI3	*Mitella diphylla*	Twin-leaf Mitrewort	Saxifragaceae	5	4	6	forb														
MOCL	*Monarda clinopodia*	Basil Bee-Balm	Lamiaceae	5	3	4	forb														
MOFI	*Monarda fistulosa*	Wild Bergamot	Lamiaceae	5	5	3	forb														
MORU2	*Morus rubra*	Red Mulberry	Moraceae	5	4	7	tree			0.26	0.22									0.86	
MUSO	*Muhlenbergia sobolifera*	Rock Muhly	Poaceae	5	5	8	grass														
NAPS	*Narcissus pseudonarcissus*	Daffodil	Liliaceae	3	2	0	forb														
NYSY	*Nyssa sylvatica*	Blackgum	Cornaceae	5	3	7	tree				1.99						2.06			2.37	
OEFR	*Oenothera fruticosa*	Narrowleaf Evening Primrose	Onagraceae	5	3	4	forb														
OEPI2	*Oenothera pilosella*	Meadow Evening Primrose	Onagraceae	5	3	3	forb														
ONSE	*Onoclea sensibilis*	Sensitive Fern	Dryopteridaceae	5	2	2	fern														
OPVU	*Ophioglossum vulgatum*	Southern Adderstongue	Ophioglossaceae	5	2	6	fern														

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ORVU	*Origanum vulgare*	Wild Marjorum	Lamiaceae	2	5	0	forb														
ORUM	*Ornithogalum umbellatum*	Star of Bethlehem	Liliaceae	1	4	0	forb	I													
OSLO	*Osmorhiza longistylis*	Longstyle Aniseroot	Apiaceae	5	4	4	forb														
OSCI	*Osmunda cinnamomea*	Cinnamon Fern	Osmundaceae	5	2	6	fern														
OXGR	*Oxalis grandis*	Great Yellow Woodsorrel	Oxalidaceae	5	5	7	forb														
OXST	*Oxalis stricta*	Common Yellow Oxalis	Oxalidaceae	4	5	0	forb														
OXVI	*Oxalis violacea*	Violet Wooodsorrel	Oxalidaceae	5	5	6	forb														
OXAR	*Oxydendrum arboreum*	Sourwood	Ericaceae	5	5	7	tree			0.96	0.45									0.79	
PAAN6	*Packera anonyma*	Small's Ragwort	Asteraceae	5	5	2	forb														
PAAU3	*Packera aurea*	Golden Ragwort	Asteraceae	5	2	4	forb														
PAGL17	*Packera glabella*	Butterweed	Asteraceae	1	1	0	forb	AI													
PAPA20	*Packera paupercula*	Balsam Groudsel	Asteraceae	5	3	9	forb	T													
PAQU	*Panax quinquefolius*	American Ginseng	Araliaceae	5	5	6	forb														
PAAN	*Panicum anceps*	Beaked Panicgrass	Poaceae	5	3	3	grass														
PAVI2	*Panicum virgatum*	Switchgrass	Poaceae	5	3	4	grass														
PACA11	*Paronychia canadensis*	Smooth Forked Nailwort	Caryophyllaceae	5	5	5	forb														
PAQU2	*Parthenocissus quinquefolia*	Virgina Creeper	Vitaceae	5	4	2	vine		5.35	0.77	4.52		1.02		4.55	7.31	3.15	12.4		6.25	
PAPU5	*Paspalum pubiflorum*	Hairyseed Paspalum	Poaceae	5	3	3	grass														
PATO2	*Paulownia tomentosa*	Princesstree	Scrophulariaceae	1	5	0	tree														
PEDI	*Penstemon digitalis*	Foxglove Beardtongue	Scrophulariaceae	5	2	3	forb														

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PESE6	*Penthorum sedoides*	Dtich Stonecrop	Crassulaceae	5	2	2	forb														
PHPU3	*Phacelia purshii*	Miami Mist	Hydrophylleaceae	5	5	4	forb														
PHHE11	*Phegopteris hexagonoptera*	Broad Beechfern	Thelypteridaceae	5	3	7	fern														
PHPR3	*Phleum pratense*	Timothy	Poaceae	1	4	0	grass														
PHDI5	*Phlox divaricata*	Wild Blue Phlox	Plolemoniaceae	5	4	4	forb														
PHLE5	*Phryma leptostachya*	American Lopseed	Verbenaceae	5	5	5	forb														
PHHE5	*Physalis heterophylla*	Clammy Groundcherry	Solanaceae	5	5	1	forb														
PHOP	*Physocarpus opulifolius*	Common Ninebark	Rosaceae	5	2	4	shru														0.86	
PHAM4	*Phytolacca americana*	American Pokeweed	Phytolaccaceae	5	4	1	forb														
PIPU2	*Pilea pumila*	Canadian Clearweed	Urticaceae	5	2	2	forb														
PIRE	*Pinus resinosa*	Red Pine	Pinaceae	3	4	0	tree											83.9			
PIRI	*Pinus rigida*	Pitch Pine	Pinaceae	5	4	7	tree													4.71	
PIST	*Pinus strobus*	Eastern White Pine	Pinaceae	5	4	6	tree						12.1					60.0			
PIVI2	*Pinus virginiana*	Virginia Pine	Pinaceae	5	5	3	tree			2.07	1.9		58.1	37.0			3.71		24.7	14.1	63.9
PIAV	*Piptochaetium avenaceum*	Blackseed Speargrass	Poaceae	5	5	8	grass	E													
PLLA	*Plantago lanceolata*	Narrowleaf Plantain	Plantaginaceae	1	5	0	forb														
PLRU	*Plantago rugelii*	Rugel's Plantain	Plantaginaceae	2	4	0	forb														
PLVI	*Plantago virginica*	Virginia Plantain	Plantaginaceae	5	5	1	forb														
PLLA2	*Platanthera lacera*	Green Fringed Orchid	Orchidaceae	5	2	3	forb														
PLOC	*Platanus occidentalis*	American Sycamore	Platanaceae	5	2	7	tree		18.6	0.3	4.95				9.63	32.8	19.2		36.4	5.56	

LIST OF VASCULAR PLANT SPECIES FOUND WITHIN THE DOE PORTS STUDY AREA DURING THE 2011 AND 2012 GROWING SEASONS

									Importance Value by Vegetated Habitat Type													
Field Code	*Taxon*	Common Name	Family	NATIVITY	WETLAND INDEX	C of C	FORM	Special Status	BLHF	Mature Oak-Hickory Forest	Mixed Mesic Forest	Mowed Maintained	Native Pine	Oldfield - Successional	Palustrine Emergent Wetland	Palustrine Forested Wetland	Palustrine Shrub-Scrub Wetland	Planted Pine	Ruderal Successional	Successional Forest	Successional Scrub
POPA2	*Poa palustris*	Fowl Bluegrass	Poaceae	5	2	5	grass														
POPR	*Poa pratensis*	Kentucky Bluegrass	Poaceae	3	4	0	grass														
POTR2	*Poa trivialis*	Rough Bluegrass	Poaceae	1	2	0	grass														
POPE	*Podophyllum peltatum*	Mayapple	Berberidaceae	5	4	4	forb														
PORE2	*Polemonium reptans*	Greek Valerian	Polemoniaceae	5	4	5	forb														
POIN4	*Polygala incarnata*	Procession Flower	Polygalaceae	5	5	6	forb	E													
POSA3	*Polygala sanguinea*	Purple Milkwort	Polygalaceae	5	4	2	forb														
POBI2	*Polygonatum biflorum*	Smooth Solomon's Seal	Liliaceae	5	4	4	forb														
POPU4	*Polygonatum pubescens*	Hairy Solomon's Seal	Liliaceae	5	5	5	forb														
POAM8	*Polygonum amphibium*	Water Knotweed	Polygonaceae	5	1	4	forb														
POAR6	*Polygonum arifolium*	Halberdleaf Tearthumb	Polygonaceae	5	1	4	forb														
POCO1	*Polygonum convolvulus*	Black Bindweed	Polygonaceae	1	4	0	vine														
POHY	*Polygonum hydropiper*	Water-pepper	Polygonaceae	5	1	1	forb														
POHY2	*Polygonum hydropiperoides*	Swamp Smartweed	Polygonaceae	5	1	6	forb														
POLA4	*Polygonum lapathifolium*	Curlytop Knotweed	Polygonaceae	5	2	1	forb														
POPE2	*Polygonum pensylvanicum*	Pennsylvania Smartweed	Polygonaceae	4	2	0	forb														
POPE3	*Polygonum persicaria*	Spotted ladysthumb	Polygonaceae	1	2	0	forb														
POPU5	*Polygonum punctatum*	Dotted Water-pepper	Polygonaceae	5	1	6	forb														
POSA5	*Polygonum sagittatum*	Arrowleaf Tearthumb	Polygonaceae	5	1	2	forb														
POSC3	*Polygonum scandens*	Climbing False Buckwheat	Polygonaceae	5	3	2	vine		0.49												

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POVI2	*Polygonum virginianum*	Virginia Jumpseed	Polygonaceae	5	3	3	forb														
POCA11	*Polymnia canadensis*	Whiteflower Leafcup	Asteraceae	5	5	5	forb														
POAC4	*Polystichum acrostichoides*	Christmas Fern	Dryopteraceae	5	5	3	fern														
PODE3	*Populus deltoides*	Eastern Cottonwood	Salicaceae	5	3	3	tree		1.93						21.9	10.9	1.6				
POTR5	*Populus tremuloides*	Quaking Aspen	Salicaceae	5	4	2	tree				0.29										
PONA4	*Potamogeton natans*	Common Pondweed	Potomogetonace	5	1	8	forb	PT													
POAR8	*Potentilla argentea*	Silver Cinquefoil	Asteraceae	1	5	0	forb														
POSI2	*Potentilla simplex*	Common Cinquefoil	Rosaceae	5	5	1	forb														
PRAL2	*Prenanthes alba*	White Lettuce	Asteraceae	5	4	5	forb														
PRAL3	*Prenanthes altissima*	Tall Rattlesnakeroot	Asteraceae	5	5	4	forb														
PRSE	*Prenanthes serpentaria*	Cankerweed	Asteraceae	5	5	5	forb								3.87						
PRVU	*Prunella vulgaris*	Common Selfheal	Lamiaceae	4	4	0	forb									0.78					
PRSE2	*Prunus serotina*	Wild Black Cherry	Rosaceae	5	4	3	tree		8.82	3.12	11.9		1.02		4.52	1.93	11.8	5.58	6.57	11.6	7.41
PYTE	*Pycnanthemum tenuifolium*	Narrowleaf Mountainmint	Lamiaceae	5	2	4	forb														
PYVI	*Pycnanthemum virginianum*	Virginia Mountainmint	Lamiaceae	5	3	4	forb														
PYAM	*Pyrola americana*	American Wintergreen	Pyrolaceae	5	3	7	forb														
PYEL	*Pyrola elliptica*	Waxflower shinleaf	Pyrolaceae	5	5	7	forb														
QUAL	*Quercus alba*	White Oak	Fagaceae	5	5	6	tree		1.88	48.2	7.55		10.8	3.42						2.17	4.69
QUCO2	*Quercus coccinea*	Scarlet Oak	Fagaceae	5	5	6	tree			6.03	1.38		5.25								
QUIM	*Quercus imbricaria*	Shingle Oak	Fagaceae	5	3	5	tree		1.91	0.86	3.66		3.27	6.06		1.89	19.3		14.3	2.95	4.69

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QUMA3	*Quercus marilandica*	Blackjack Oak	Fagaceae	5	5	8	tree	PT		15.0	2.84		11.6	4.73						4.95	6.89
QUMI	*Quercus michauxii*	Swamp Chestnut Oak	Fagaceae	NA	2	NA	tree														
QUMU	*Quercus muehlenbergii*	Chinkapin Oak	Fagaceae	5	5	7	tree		0.65	0.26	0.37					0.76				5.54	
QUPA2	*Quercus palustris*	Pin Oak	Fagaceae	5	2	5	tree		0.92												
QUPR2	*Quercus prinus*	Chestnut Oak	Fagaceae	5	5	7	tree			13.2			6.28								
QURU	*Quercus rubra*	Northern Red Oak	Fagaceae	5	5	6	tree		3.25	13.3	2.94		4.11							2.67	5.79
QUST	*Quercus stellata*	Post Oak	Fagaceae	5	5	7	tree			5.94	1.74		5.32	2.55			1.76		7.77		7.52
QUTR	*Quercus tridentata*	*Proposed Species*	Fagaceae	5	4	NA	tree		0.79		0.22										
QUVE	*Quercus velutina*	Black Oak	Fagaceae	5	5	7	tree		5.19	18.4	3.8		7.15							1.56	
RHCO	*Rhus copallinum*	Winged Sumac	Anacardiaceae	5	5	4	shru							10.5					5.85		27.2
RHGL	*Rhus glabra*	Smooth Sumac	Anacardiaceae	5	5	2	shru										2.99				
RICY	*Ribes cynosbati*	Eastern Prickly Gooseberry	Grossulariaceae	5	5	3	shru														
ROPS	*Robinia psuedoacacia*	Black Locust	Fabaceae	4	5	0	tree			0.34	1.35			4.53		0.88	7.09			7.59	6.13
ROBL	*Rosa blanda*	Smooth Rose	Rosaceae	5	4	4	shru	PT	0.49	0.35		15.04									
ROCA4	*Rosa carolina*	Carolina Rose	Rosaceae	5	5	4	shru														
ROMU	*Rosa multiflora*	Multifloral Rose	Rosaceae	1	4	0	shru	I	36.3	3.43	25.0	15.8	3.52	17.7	28.1	42.9	10.9	5.58	9.79	21.8	5.73
ROPA	*Rosa palustris*	Swamp Rose	Rosaceae	5	1	5	shru							2.1	5.4				15.2		
ROSE2	*Rosa setigera*	Climbing Rose	Rosaceae	5	4	4	shru										4.46				
RUAL	*Rubus allegheniensis*	Allegheny Blackberry	Rosaceae	4	5	1	shru		3.81	11.5	6.72	52.1	7.82	11.2	7.44	2.3	14.7	6.81		9.82	23.4
RUFL	*Rubus flagellaris*	Northern Dewbery	Rosaceae	5	5	1	shru			1.08	1.06									1.5	

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RUHI	*Rubus hispidus*	Bristly Dewberry	Rosaceae	5	2	5	forb														
RUOC	*Rubus occidentalis*	Black Raspberry	Rosaceae	5	5	1	shru		1.54	0.38	1.55			2.29	3.87	1.88				3.48	
RUPE3	*Rubus pensilvanicus*	Pennsylvania Blackberry	Rosaceae	5	4	1	shru				0.55									1.51	
RUHI2	*Rudbeckia hirta*	Black-eyed Susan	Asteraceae	5	5	1	forb														
RULA3	*Rudbeckia lacinata*	Cutleaf Coneflower	Asteraceae	5	2	6	forb														
RUCA4	*Ruellia caroliniensis*	Carolina Wild Petunia	Acanthaceae	5	5	4	forb														
RUST2	*Ruellia strepens*	Limestone Wild Petunia	Acanthaceae	5	3	5	forb														
RUAC3	*Rumex acetosella*	Common Sheep Sorrel	Polygonaceae	1	5	0	forb														
SACA5	*Salix caroliniana*	Coastal Plain Willow	Salicaceae	5	1	10	shru	PT								0.89					
SADI	*Salix discolor*	Pussy Willow	Salicaceae	5	2	3	shru														
SAIN3	*Salix interior*	Sandbar Willow	Salicaceae	5	1	1	shru							2.24	86.8	0.71	9.34		24.9		
SANI	*Salix nigra*	Black Willow	Salicaceae	5	2	2	tree														
SASE	*Salix sericea*	Silky Willow	Salicaceae	5	1	4	shru										16.9		17.0		
SALY2	*Salvia lyrata*	Lyreleaf Sage	Labiaceae	5	5	3	forb														
SANI4	*Sambucus nigra*	Common Elderberry	Caprifoliaceae	5	2	3	shru		2.33					2.38		0.71		6.19		0.86	
SACA13	*Sanguinaria canadensis*	Bloodroot	Papaveraceae	5	5	5	forb														
SACA15	*Sanicula canadensis*	Canadian Blacksnakeroot	Apiaceae	5	5	3	forb														
SAMA2	*Sanicula marilandica*	Maryland Sanicle	Apiaceae	5	5	3	forb														
SATR4	*Sanicula trifoliata*	Largefruit Blacksnakeroot	Apiaceae	5	5	3	forb														
SAAL5	*Sassafras albidum*	Sassafras	Lauraceae	5	5	3	tree		1.44	9.21	12.0		15.2		14.8	0.76	4.43			7.9	

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SACE	*Saururus cernuus*	Lizard's Tail	Saururaceae	5	1	8	forb														
SCPU13	*Schoenoplectus purshianus*	Weakstalk bulrush	Cyperaceae	5	1	6	sedg														
SCTA2	*Schoenoplectus*	Softstem Bulrush	Cyperaceae	5	1	2	sedg														
SCAT2	*Scirpus atrovirens*	Green Bulrush	Cyperaceae	5	1	1	sedg														
SCCY	*Scirpus cyperinus*	Woolgrass	Cyperaceae	5	2	1	sedg														
SCMA2	*Scrophularia marilandica*	Carpenter's Square	Scrophulariaceae	5	5	4	forb														
SCEL	*Scutellaria elliptica*	Hairy Skullcap	Lamiaceae	5	5	5	forb														
SCGA	*Scutellaria galericulata*	Marsh Skullcap	Lamiaceae	5	1	6	forb														
SCIN	*Scutellaria incana*	Hoary Skullcap	Lamiaceae	5	5	4	forb														
SCIN2	*Scutellaria integrifolia*	Hyssop Skullcap	Lamiaceae	5	2	6	forb														
SCNE2	*Scutellaria nervosa*	Veiny Skullcap	Lamiaceae	5	3	6	forb														
SCPA7	*Scutellaria parvula*	Small Skullcap	Lamiaceae	5	5	6	forb														
SEVA4	*Securigera varia*	Crown Vetch	Fabaceae	1	5	0	forb	I													
SETE3	*Sedum ternatum*	Woodland Stonecrop	Crassulaceae	5	5	5	forb														
SEAS3	*Sericocarpus asteroides*	Toothed Whitetop Aster	Asteraceae	5	5	4	forb														
SEVI4	*Setaria viridis*	Green Bristlegrass	Poaceae	3	5	0	grass														
SIVI4	*Silene virginica*	Fire Pink	Caryophyllaceae	5	5	5	forb														
SIOF	*Sisymbrium officinale*	Hedgemustard	Brassicaceae	1	5	0	forb														
SIAN3	*Sisyrinchium angustifolium*	Narrowleaf Blue-Eyed Grass	Iridaceae	5	2	2	forb														
SMGL	*Smilax glauca*	Cat Greebrier	Smilacaceae	5	4	5	vine		1.04	2.38	2.49		4.77							0.94	5.21

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SMRO	*Smilax rotundifolia*	Round-leaf Greenbrier	Smilacaceae	5	3	4	vine		5.76	13.3	6.27		14.5		4.16		3.49	4.96		3.39	
SMTA2	*Smilax tamnoides*	Bristly Greenbrier	Smilacaceae	5	3	3	vine		0.52	0.63	1.15			2.18		1.49	4.54			1.81	
SOCA3	*Solanum carolinense*	Carolina Horsenettle	Solanaceae	1	5	0	forb														
SOAL6	*Solidago altissima*	Tall Goldenrod	Asteraceae	5	5	1	forb														
SOCA4	*Solidago caesia*	Wreath Goldenrod	Asteraceae	5	4	5	forb														
SOCA6	*Solidago canadensis*	Canada Goldenrod	Asteraceae	5	4	1	forb														
SOGI	*Solidago gigantea*	Giant Goldenrod	Asteraceae	5	2	3	forb														
SOHI	*Solidago hispida*	Hairy Goldenrod	Asteraceae	5	5	4	forb														
SOJU	*Solidago juncea*	Early Goldenrod	Asteraceae	5	5	2	forb														
SONE	*Solidago nemoralis*	Gray Goldenrod	Asteraceae	5	5	2	forb														
SOOD	*Solidago odora*	Anisescented Goldenrod	Asteraceae	5	5	8	forb	T													
SOUL	*Solidago uliginosa*	Bog Goldenrod	Asteraceae	5	1	9	forb														
SOAS	*Sonchus asper*	Spiny Sowthistle	Asteraceae	1	5	0	forb														
SONU2	*Sorghastrum nutans*	Indiangrass	Poaceae	5	5	5	grass														
SOHA	*Sorghum halepense*	Johnsongrass	Poaceae	1	4	0	grass	I													
SPAM	*Sparganium americanum*	American Bur-reed	Sparganiaceae	5	1	6	forb														
SPEU	*Sparganium eurycarpum*	Broadfruit Bur-reed	Sparganiaceae	5	1	4	forb														
SPTO2	*Spiraea tomentosa*	Steeplebush	Rosaceae	5	2	4	shru														
SPCE	*Spiranthes cernua*	Nodding Landy's Tresses	Orchidaceae	5	2	4	forb														
SPVE	*Spiranthes vernalis*	Spring's Lady's Tresses	Orchidaceae	5	3	7	forb														

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STGR	*Stellaria graminea*	Grass-like Starwort	Caryophyllaceae	1	5	0	forb														
STME2	*Stellaria media*	Common Chickweed	Caryophyllaceae	1	5	0	forb														
STPU	*Stellaria pubera*	Star Chickweed	Caryophyllaceae	5	5	5	forb														
STSE3	*Stipulicida setacea*	Pineland Scalypink	Caryophyllaceae	NA	3	NA	forb														
STPE15	*Stuckenia pectinata*	Fennel-leaved Pondweed	Potomogetonace	5	1	2	forb														
STBI2	*Stylosanthes biflora*	Sidebeak Pencilflower	Fabaceae	5	5	3	forb														
SYCO4	*Symphyotrichum cordifolium*	Common Blue Wood Aster	Asteraceae	5	5	4	forb														
SYER	*Symphyotrichum ericoides*	White Heath Aster	Asteraceae	5	4	2	forb														
SYLA4	*Symphyotrichum lateriflorum*	Calico Aster	Asteraceae	5	2	2	forb														
SYLO2	*Symphyotrichum lowrieanum*	Lowery's Blue Wood Aster	Asteraceae	5	5	6	forb														
SYNO2	*Symphyotrichum novae-*	New England Aster	Asteraceae	5	2	2	forb														
SYPI2	*Symphyotrichum pilosum*	Hairy White Oldfield Aster	Asteraceae	5	5	1	forb														
SYPR6	*Symphyotrichum*	Crookedstem Aster	Asteraceae	5	3	4	forb														
SYPU	*Symphyotrichum puniceum*	Purple-stem Aster	Asteraceae	5	1	7	forb														
TAOF	*Taraxacum officinale*	Common Dandelion	Asteraceae	5	5	0	forb														
TECA3	*Teucrium canadense*	American Germander	Lamiaceae	2	2	3	forb														
THPU2	*Thalictrum pubescens*	King of the Meadow	Ranunuculaceae	5	2	5	forb														
THTH2	*Thalictrum thalictroides*	Rue Anemone	Ranunuculaceae	5	5	6	forb														
THNO	*Thelypteris novaboracensis*	New York Fern	Thelypteridaceae	5	3	4	fern														
TIAM	*Tilia americana*	American Basswood	Tiliaceae	5	4	6	tree			0.26											

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TIAMH	*Tilia americana var.*	White Basswood	Tiliaceae	5	4	6	tree				0.26										
TORA2	*Toxicodendron radicans*	Poison Ivy	Anacardiaceae	5	3	1	vine		5.23	1.55	2.54		5.33	2.51	6.13	8.73	5.05			4.59	
TOVE	*Toxicodendron vernix*	Poison Sumac	Anacardiaceae	5	1	7	shru														
TRDU	*Tragopogon dubius*	Yellow Salisify	Asteraceae	1	5	0	forb														
TROH	*Transcantia ohiensis*	Ohio Spiderwort	Commelinaceae	5	3	5	forb														
TRFL2	*Tridens flavus*	Purpletop Tridens	Poaceae	5	4	1	grass														
TRCA5	*Trifolium campestre*	Field Clover	Fabaceae	1	5	0	forb														
TRDU2	*Trifolium dubium*	Least Hop Clover	Fabaceae	1	5	0	forb														
TRPR2	*Trifolium pratense*	Red Clover	Fabaceae	1	5	0	forb														
TRRE3	*Trifolium repens*	White clover	Fabaceae	1	5	0	forb														
TRGR4	*Trillium grandiflorum*	White Trillium	Liliaceae	5	5	5	forb														
TRPE4	*Triodanis perfoliata*	Clasping Venus' Looking-glass	Campanulaceae	5	3	2	forb														
TYAN	*Typha angustifolia*	Narrowleaf Cattail	Typhaceae	1	1	0	forb	I													
TYLA	*Typha latifolia*	Broadleaf Cattail	Typhaceae	5	1	1	forb														
ULAM	*Ulmus americana*	American Elm	Ulmaceae	5	2	2	tree		2.45	0.26	2.73				3.87	4.85	15.7			5.45	
ULRU	*Ulmus rubra*	Slippery Elm	Ulmaceae	5	3	3	tree		6.11	0.26	4.28					2.76				1.92	
URDID	*Urtica dioica ssp. dioica*	Stinging Nettle	Urticaceae	1	4	0	forb														
URDIG	*Urtica dioica ssp. gracilis*	Tall Nettle	Urticaceae	5	3	1	forb														
UVGR	*Uvularia grandiflora*	Largeflower Bellwort	Liliaceae	5	5	5	forb														
UVPE	*Uvularia perfoliata*	Perfoliate Bellwort	Liliaceae	5	4	5	forb														

LIST OF VASCULAR PLANT SPECIES FOUND WITHIN THE DOE PORTS STUDY AREA DURING THE 2011 AND 2012 GROWING SEASONS

Field Code	*Taxon*	Common Name	Family	NATIVITY	WETLAND INDEX	C of C	FORM	Special Status	Importance Value by Vegetated Habitat Type												
									BLHF	Mature Oak-Hickory Forest	Mixed Mesic Forest	Mowed Maintained	Native Pine	Oldfield - Successional	Palustrine Emergent Wetland	Palustrine Forested Wetland	Palustrine Shrub-Scrub Wetland	Planted Pine	Ruderal Successional	Successional Forest	Successional Scrub
UVSE	*Uvularia sessilifolia*	Sessileleaf Bellwort	Liliaceae	5	5	5	forb														
VACO	*Vaccinium corymbosum*	High-bush Blueberry	Ericaceae	5	2	6	shru		0.52	0.48											
VAPA4	*Vaccinium pallidum*	Blue Ridge Blueberry	Ericaceae	5	5	6	shru			8.2			16.0							1.6	
VAST	*Vaccinium stamineum*	Deerberry	Ericaceae	5	5	6	shru			6.17			6.04	2.29							
VARA	*Valerianella radiata*	Beaked Cornsalad	Valerianaceae	4	3	0	forb														
VETH	*Verbascum thapsus*	Common Mullein	Scrophulariaceae	1	5	0	forb														
VEHA2	*Verbena hastata*	Swamp Vervain	Verbenaceae	5	2	4	forb														
VEUR	*Verbena urticifolia*	White Vervain	Verbenaceae	5	4	3	forb														
VEAL	*Verbesina alternifolia*	Wingstem	Asteraceae	5	3	5	forb														
VEGI	*Vernonia gigantea*	Giant Ironweed	Asteraceae	5	3	2	forb														
VEOF2	*Veronica officinalis*	Common Speedwell	Scrophulariaceae	1	5	0	forb														
VIDE	*Viburnum dentatum*	Southern Arrowwood	Caprifoliaceae	5	3	2	shru			0.26	0.47								16.7	3.61	
VIPR	*Viburnum prunifolium*	Blackhaw	Caprifoliaceae	5	4	4	shru		2.19	0.3	1.99					4.03	4.75				
VIRE7	*Viburnum recognitum*	Southern Arrowwood	Caprifoliaceae	5	2	2	shru														
VISA	*Vicia sativa*	Garden Vetch	Fabaceae	1	5	0	forb														
VIAR	*Viola arvensis*	European Field Pansy	Violaceae	1	5	0	forb														
VIBI	*Viola bicolor*	Field Pansy	Viola	5	5	2	forb														
VICA4	*Viola canadensis*	Canada White Violet	Violaceae	5	5	5	forb														
VICU	*Viola cucullata*	Marsh Violet	Violaceae	5	2	6	forb														
VIPU3	*Viola pubescens*	Downy Yellow Violet	Violaceae	5	5	4	forb														

LIST OF VASCULAR PLANT SPECIES FOUND WITHIN THE DOE PORTS STUDY AREA DURING THE 2011 AND 2012 GROWING SEASONS

									Importance Value by Vegetated Habitat Type												
Field Code	*Taxon*	Common Name	Family	NATIVITY	WETLAND INDEX	C of C	FORM	Special Status	BLHF	Mature Oak-Hickory Forest	Mixed Mesic Forest	Mowed Maintained	Native Pine	Oldfield - Successional	Palustrine Emergent Wetland	Palustrine Forested Wetland	Palustrine Shrub-Scrub Wetland	Planted Pine	Ruderal Successional	Successional Forest	Successional Scrub
VISA2	*Viola sagittata*	Arrowleaf Violet	Violaceae	5	2	4	forb														
VISO	*Viola sororia*	Common Blue Violet	Violaceae	5	3	1	forb														
VIST3	*Viola striata*	Striped Cream Violet	Violaceae	5	2	5	forb														
VITR2	*Viola triloba*	Three-lobe violet	Violaceae	5	2	4	forb														
VIAE	*Vitis aestivalis*	Summer Grape	Vitaceae	5	4	4	vine		1.68	1.53	3.51		3.2	2.1						3.61	
VILA8	*Vitis labrusca*	Fox Grape	Vitaceae	5	4	3	vine				0.52						1.46			1.6	
VIRI	*Vitis riparia*	Riverbank Grape	Vitaceae	5	2	3	vine		3.73	0.26	0.38	16.55			4.29	7.11	3.59			0.79	
VIVU	*Vitis vulpina*	Frost Grape	Vitaceae	5	3	3	vine			0.26	1.31					3.05		16.1		2.23	
WOAR	*Woodwardia areolata*	Netted Chainfern	Blechnaceae	5	2	6	fern														
XAST	*Xanthium strumarium*	Cocklebur	Asteraceae	4	3	0	forb														
ZIAP	*Zizia aptera*	Meadow Zizia	Apiaceae	5	3	7	forb														

Appendix D Summary of Wildlife Signs

D.1 Field-Observed Habitat Features

Of the observable features noted during field operations, researchers recorded evidence of:

- The number of holes or cavities in standing woody vegetation
- The presence of loose attached bark on mature trees
- Rocky holes, cracks, overhangs and/or crevices
- Light soil with burrows present
- Raptors perches present
- As well as any other notable features

The number of open holes or cavities occurring in standing woody vegetation was recorded in the field as: none, few, some, or many. These features provide physical nesting habitat for many of the forest-dwelling animals that potentially exist in our Eastern Deciduous Hardwood Forests. While it is often difficult to determine whether a hole or cavity is presently being utilized by an animal, many were observed with animal residents in or near the site. Birds, specifically woodpeckers, were the most common occupant of woody holes. Small mammals also utilize these habitat features for a variety of purposes.

Most of the forested plots were composed of at least a few trees that offered woody cavities for animals to use as habitat. The successional forest samples offered some or many woody holes in half of all plots, while the other half offered at least a few. In descending order of availability of woody holes offered by habitat includes: successional forest, mixed mesophytic forest, bottomland hardwood forest, oak-hickory forest, native pine forest, and palustrine forested wetland offering no cavities for habitat in 31% of all plots.

The presence of loose woody bark, particularly on species such as shagbark hickory (*Carya ovate*), white oak (*Quercus alba*), and American sycamore (*Platanus occidentalis*), provide habitat for many bat species that inhabit our hardwood forests. Bats such as the big brown bat (Eptesicus fuscus) and the Federally-endangered Indiana Bat (*Myotis sodalis*), seek daytime roosts under the loose bark of mature trees. Considering that 26.2% of the study area was covered by the oak-hickory forest type, many mature loose-bark trees were available for animals to find shelter and daytime roosts. In fact, the oak-hickory forests offered mature loose-bark trees in 78% of the plots surveyed. Loose-bark trees were also noted in 77% of all palustrine forested wetland plots, 75% of all bottomland hardwood forest plots, but only 47% of all mixed mesic forest plots.

Predatory raptor bird species are frequent residents within the region. While various raptor species have differing habitat requirements, many of them utilize high open branches of mature trees to scout for potential prey. These features were observed during this survey and noted for each plot. Raptor perches were most frequent in palustrine emergent wetland plots occurring 75% of the time. While most emergent wetland habitats are characterized by sparse tree cover, PORTS wetlands typically host one or more mature trees. These trees are commonly fast-growing species, such as Populus deltoides, and achieve considerable height. Lone mature trees found within the transition zone between habitats can provide ideal perches for raptors.

Oak-Hickory forest, bottomland hardwood forest, and palustrine forested wetland plots each hosted conspicuous raptor perches in 61-62% of those plots surveyed. Since, these forest habitats had to demonstrate considerable openness in the understory in order to be tallied for potential raptor perches, this measure also indicates that much of the forest habitat in the study area is characterized by more open understory structure. Mixed mesic forest habitats produced raptor perch tallies in only 49% of those plots surveyed and 29% in native pine habitat.

While rocky holes, openings, or overhangs provide habitat for animal species, soil burrows are an indication of subsurface habitation. Rocky features provided potential habitat in 62.5% of all bottomland hardwood forest plots, 46% of all palustrine forested wetland plots, 29% of all successional forest plots, and less than 20% in all other habitats. Considering that the bedrock geology consisting of shale and sandstone do not typically outcrop in this region, it is not typical to find an abundance of rocky niches. Soil burrows were also quite uncommon, being found in only 17 out of 150 plots surveyed. Burrows were most observed in the mixed mesic forest habitats, however occurring in only 17% of the plots surveyed.

D.2 Field-Observed Wildlife Signs

While the primary impetus of this survey was to evaluate the vegetation of the study area to characterize the physical habitats, observation of the inhabitants of those various covers were noted. Signs of animal life observed included:

- Actual sightings of animals
- Audible calls/sounds of animals
- Physical evidence of their presence like
  - Feathers or fur
  - Corpse or bone
  - Scat or pellet
- Evidence of animal activity like
  - Scratches or chew marks
  - Dens or burrows
  - Scrape or rub
  - Trail or run

Having noted these features only in vegetation plots or in transit to the next sample point when possible, these observations do not represent a comprehensive distribution of animal species within the study area. All of the species observations are provided in Table D.1 listed chronologically. These observations were categorized after-the-fact based on the assemblage of species observed during the study. Figure D.1 illustrates the distribution of animal feature observations noted on field forms, in field notebooks, or captured using GPS. To facilitate the presentation of these observations, species were grouped by principal characteristics including:

- Amphibians (5 species, 7 occurrences)
- Reptiles (10 species, 21 occurrences)

- Game birds (5 species, 18 occurrences)
- Song birds (12 species, 16 occurrences)
- Woodpeckers (5 species, 10 occurrences)
- Raptor/Predator/Scavenger Birds (6 species, 13 occurrences)
- Insects (16 species, 22 occurrences)
- Mammals (11 species , 59 occurrences)
- Deer ticks only (5 occurrences)
- White-tailed deer only (34 occurrences)

Table D.1 List of Faunal Species Observed at PORTS

Common Name	Species Name	Life Form
American Toad	*Anaxyrus americanus*	Amphibian
Fowlers Toad	*Anaxyrus fowleri*	Amphibian
Northern Green Frog	*Lithobates clamitans melanota*	Amphibian
Northern Spring Peeper	*Pseudacris crucifer crucifer*	Amphibian
Red-spotted Newt	*Notophthalmus vrirdescens*	Amphibian
Canada Goose	*Branta canadensis*	Game bird
Northern Bobwhite	*Colinus virginianus*	Game bird
Ruffed Grouse	*Bonasa umbellus*	Game bird
Wild Turkey	*Meleagris gallopavo*	Game bird
Wood Duck	*Aix sponsa*	Game bird
Bee-like Robber Fly	*Laphria thoracica*	Insect
Black-legged Tick	*Ixodes scapularis*	Insect
Common Buckeye	*Junonia coenia*	Insect
Copper Underwing	*Amphipyra pyramidoides*	Insect
Eastern Hercules Beetle	*Dynastes tityus*	Insect
Ebony Jewelwing	*Calopteryx maculata*	Insect
Giant Ichneunmon	*Megarhyssa greenei*	Insect
Great Spangled Fritallary	*Speyeria cybele*	Insect
Honey Bees	*Apis sp.*	Insect
Larger Empty Oak Apple Gall Wasp	*Amphibolips quercusinanis*	Insect
Monarch	*Danaus plexippus*	Insect
Protean Shieldback Katydid Nymph	*Atlanticus testaceus*	Insect
Red Admiral	*Vanessa atalanta*	Insect
Spiny Oak Slug Moth	*Euclea delphinii*	Insect
Viceroy	*Limenitis archippus*	Insect
White-blotched Heterocampa	*Heterocampa umbrata*	Insect
American Beaver	*Castor canadensis*	Mammal
Coyote	*Canis latrans*	Mammal
Eastern Chipmunk	*Tamias striatus*	Mammal
Eastern Cottontail Rabbit	*Sylvilagus floridanus*	Mammal
Eastern Gray Squirrel	*Sciurus carolinensis*	Mammal

Raccoon	*Procyon lotor*	Mammal
Red Squirrel	*Tamiassciurus hudsinicus*	Mammal
Short-tailed Shrew	*Blarina brevicauda*	Mammal
Striped Skunk	*Mephitis mephitis*	Mammal
Virginia Opossum	*Didephis virginiana*	Mammal
White-tailed Deer	*Odocoileus virginianus*	Mammal
Belted Kingfisher	*Ceryle alcyon*	Predator Bird
Green Heron	*Butorides virescens*	Predator Bird
Barred Owl	*Strix varia*	Raptor
Broad-winged Hawk	*Buteo platypterus*	Raptor
Red-tailed Hawk	*Buteo jamaicensis*	Raptor
Common Water Snake	*Nerodia sipedon sipedon*	Reptile
Eastern Black Kingsnake	*Lampropeltis getula nigra*	Reptile
Eastern Box Turtle	*Terrapene carolina carolina*	Reptile
Eastern Fence Lizard	*Sceloporus undulatus*	Reptile
Eastern Milksnake	*Lampropeltis triangulum triangulum*	Reptile
Eastern Spiny Softshell Turtle	*Apalone spinifera spinifera*	Reptile
Midland Smooth Softshell Turtle	*Apalone mutica mutica*	Reptile
Northern Black Racer	*Culuber constrictor foxii*	Reptile
Northern Ring-necked Snake	*Diadophis punctatus edwardsii*	Reptile
Snapping Turtle	*Chelydra serpentina*	Reptile
Turkey Vulture	*Cathartes aura*	Scavenger
Acadian Flycatcher	*Empidonax virescens*	Songbird
Black-throated Green Warbler	*Dendroica virens*	Songbird
Blue Jay	*Cyanocitta cristata*	Songbird
Cedar Waxwing	*Bombycilla cedrorum*	Songbird
Common Grackle	*Quiscalus quiscula*	Songbird
Eastern Phoebe	*Sayornis phoebe*	Songbird
Eastern Wood-pewee	*Contopus virens*	Songbird
Gray Catbird	*Dumetella carolinensis*	Songbird
Great -Crested Flycatcher	*Myiarchus crinitus*	Songbird
Red-eyed Vireo	*Vireo olivaceus*	Songbird
Red-winged Blackbird	*Agelaius phoeniceus*	Songbird
Scarlet Tanager	*Piranga olivacea*	Songbird
Downy Woodpecker	*Picoides pubescens*	Woodpecker
Hairy Woodpecker	*Picoides villosus*	Woodpecker
Northern Flicker	*Colaptes auratus*	Woodpecker
Pileated Woodpecker	*Dryocopus pileatus*	Woodpecker
Yellow-bellied Sapsucker	*Sphyrapicus varius*	Woodpecker

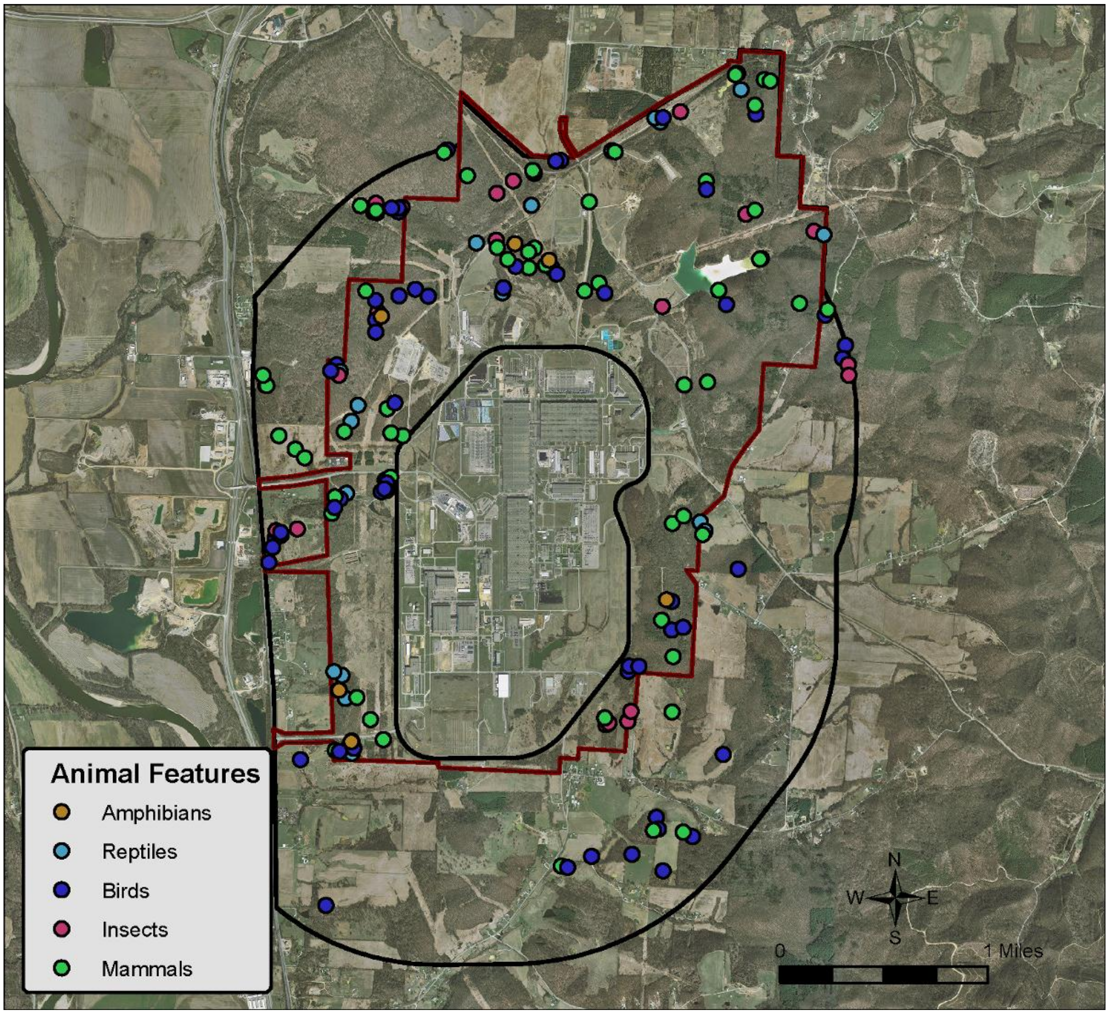

Figure D.1 Map of Observed Animal Features

D.2.1 Amphibians and Reptiles

While amphibians are mostly associated with aquatic systems, reptiles are found near aquatic environs or in dry, upland habitats (Figure D.2). In this study, numerous box turtles (*Terrapene carolina carolina*) were observed in forest habitats (Figure D.3) as lone explorers, except in one instance where a mating pair was found very near one another. Other reptiles found in the study area include the northern black racer (*Culuber constrictor foxii*), the northern ring-necked snake (*Diadophis punctatus edwardsii*) (Figure D.4), the midland smooth softshell turtle (*Apalone mutica mutica*) (Figure D.5), the eastern black kingsnake (*Lampropeltis getula nigra*) (Figure D.6), and the eastern milksnake (Figure D.7). One fairly large turtle nest was discovered with about 12 empty egg casings in the embankment of the X-230J-5 holding pond (Figure D.8). The turtle species could not be determined, but considering that snapping turtles (*Chelydra serpentine*) were the only turtles observed in other holding ponds on-site, it is assumed that the nest belongs to a snapping turtle.

While reptiles were relatively abundant throughout the study area, amphibians were less commonly encountered. The most common amphibian observed was the American toad (*Anaxyrus americanus*) and the northern green frog (*Lithobates clamitans melanota*) (Figure D.9). However, several salamanders and newts were seen along the riparian corridor of the Little Beaver Creek and scattered wetlands. The occasional northern spring peeper (*Pseudacris crucifer crucifer*) and Fowler‟s toad (*Anaxyrus fowleri*) (Figure D.10) were encountered on-site.

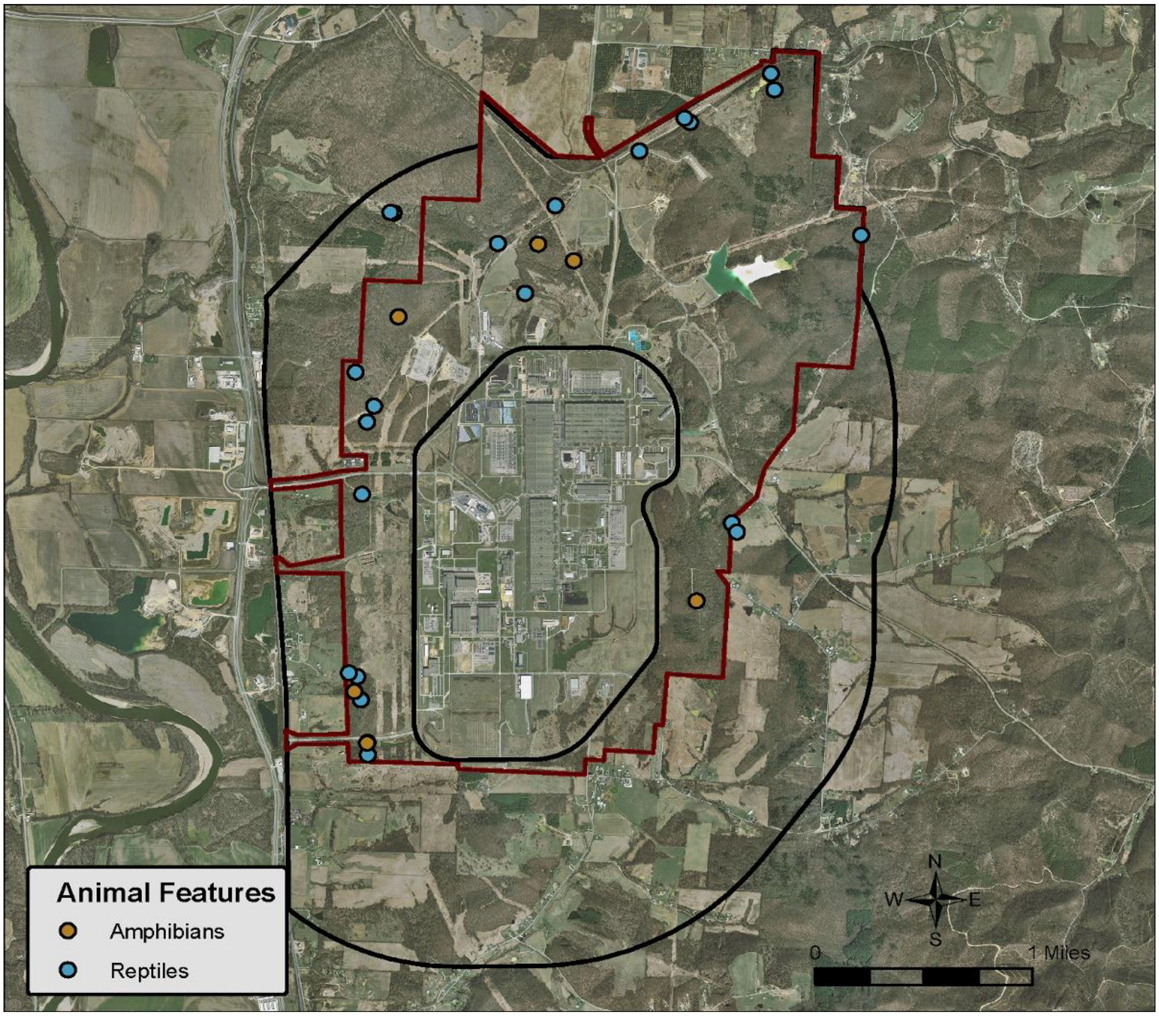

Figure D.2 Map of Observed Amphibians and Reptile Features

Figure D.3 Eastern box turtle in dry uplands

Figure D.4 Northern ring-necked snake in riparian zone of Little Beaver Creek

Figure D.5 Midland smooth softshell turtle in Little Beaver Creek

Figure D.6 Eastern black kingsnake

Figure D.7 Eastern milksnake after feeding

Figure D.8 Turtle Eggs after hatching

Figure D.9 Northern water snake facing-off with Northern green frog

Figure D.10 Fowler's toad in native pine habitat

D.2.2 Birds

Bird species were numerous throughout the study area (Figure D.11). Woodpeckers and raptors seemed to be ever-present as the study area was traversed. In the forested habitats song birds were common while signs of game birds were abundant. Pileated woodpeckers (*Dryocopus pileatus*) and wild turkey

(*Meleagris gallopavo*) were among the species most commonly encountered in the forested habitats. Some of the less commonly observed species includes green herons (*Butorides virescens*), scarlet tanager (*Piranga olivacea*), ruffed grouse (*Bonasa umbellus*), the Acadian flycatcher (*Empidonax virescens*), northern bobwhite quail (*Colinus virginianus*), and a large flock of cedar waxwings (*Bombycilla cedrorum*). Red-tailed hawks (*Buteo jamaicensis*) and broad-winged hawks (*Buteo platypterus*) were the most commonly encountered raptor species, especially utilizing perches along transitional zones

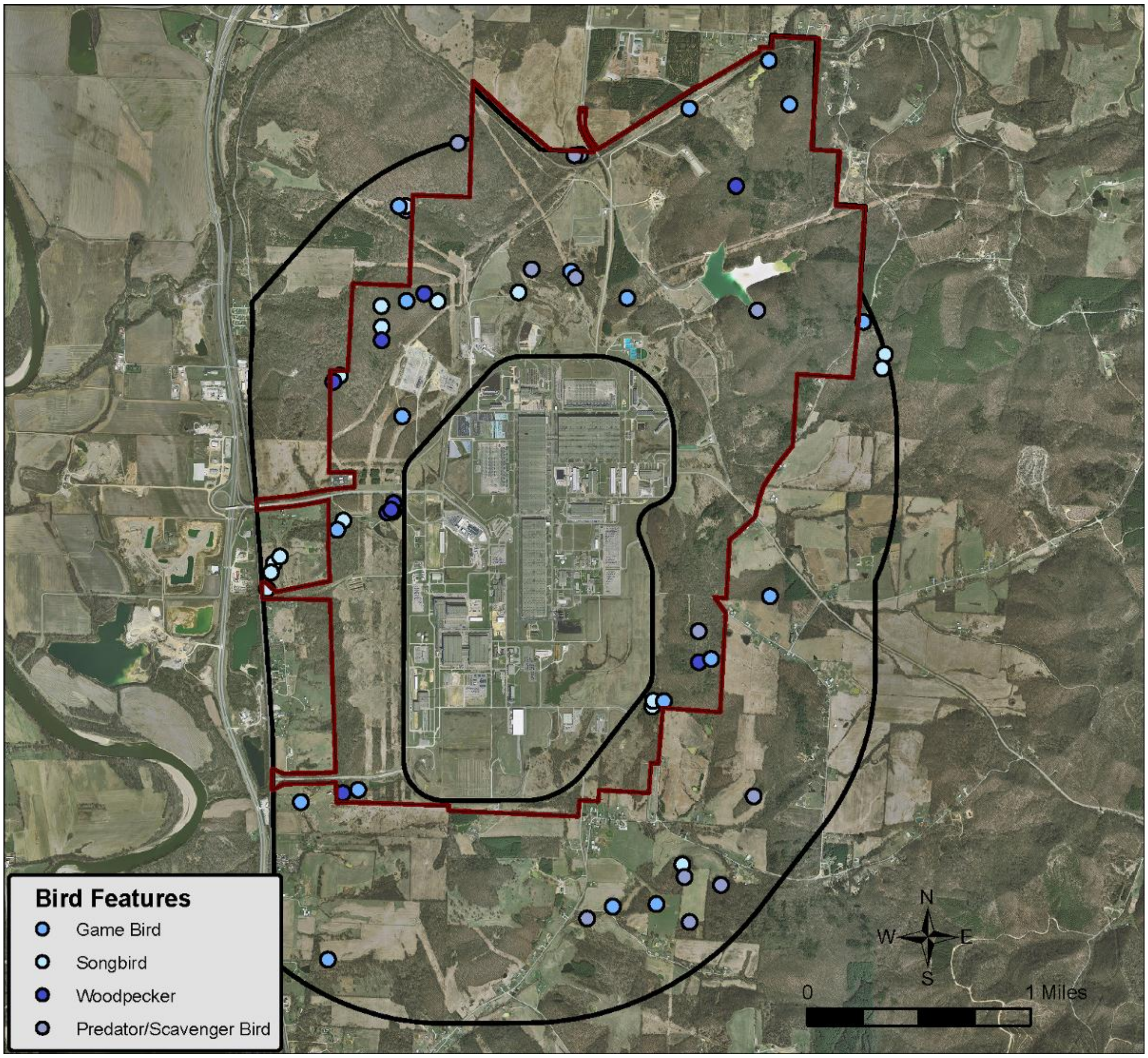

Figure D.11 Map of Bird Features

D.2.3 Insects

Many common insects were encountered during this study including mosquitoes, flies, and ticks. However, only notable insects were recorded when possible (Figure D.12). Species were recorded whenever they presented themselves long enough to be observed. Among those observed include the Eastern Hercules beetle (*Dynastes tityus*) (Figure D.13), the giant ichneumon (*Megarhyssa greenei*), the spiny oak slug moth (*Euclea delphinii*), the bee-like robber fly (*Laphria thoracica*) (Figure D.14), and the Protean shieldback katydid nymph (*Atlanticus testaceus*) (Figure D.15).

The most troublesome insect encountered during this study was the deer tick (*Ixodes scapularis*). Depending on the time of year, ticks made their presence known as a few solitary adults in the spring or fall or as masses of juveniles often less than 2mm in size, (Figure D.16) may number in the thousands during the heat of summer. The ticks were often collected involuntarily on clothing by passing along heavily traveled deer trails or habitat edges often thick with shrubby St. Johnswort (*Hypericum prolificum*).

Ticks have been linked to at least ten known diseases in humans. According to the Center for Disease Control (CDC), deer ticks pose a risk to humans by potentially transmitting the bacterium *Borrelia burgdorferi* through the bite of infected individuals. Deer ticks require an animal host for portions of its life cycle. Larval ticks, which are not born infected, seek out small mammal and bird hosts to supply the necessary blood food source. Infection of the bacterium responsible for Lyme disease most often occurs while the larval ticks feed on these first hosts. White-footed mice are a very common host for these larval ticks. Mice previously infected by tick bites serve as a reservoir to infect subsequent ticks that feed upon them as they continue the transformation into a nymph.

The nymph remains dormant through the winter and early spring emerging in late spring to seek a larger animal host. If the nymph was not previously infected as a larva, it can become infected by feeding on the blood of an infected host. Nymphs are responsible for most of the infectious bites that cause Lyme disease in humans due to their small size and density of populations. Once engorged on blood from its host, nymphs proceed to become adults. Adult deer ticks seek out larger hosts by positioning themselves several feet off the ground. The adults often find white-tailed deer during this phase of their life cycle. Infected adults can infect deer or human hosts as they engorge themselves for laying their eggs in anticipation of the changing seasons. Eggs often drop from deer hosts in and around the areas in which deer rest, feed, and move, keeping deer ticks proximal to their primary hosts.

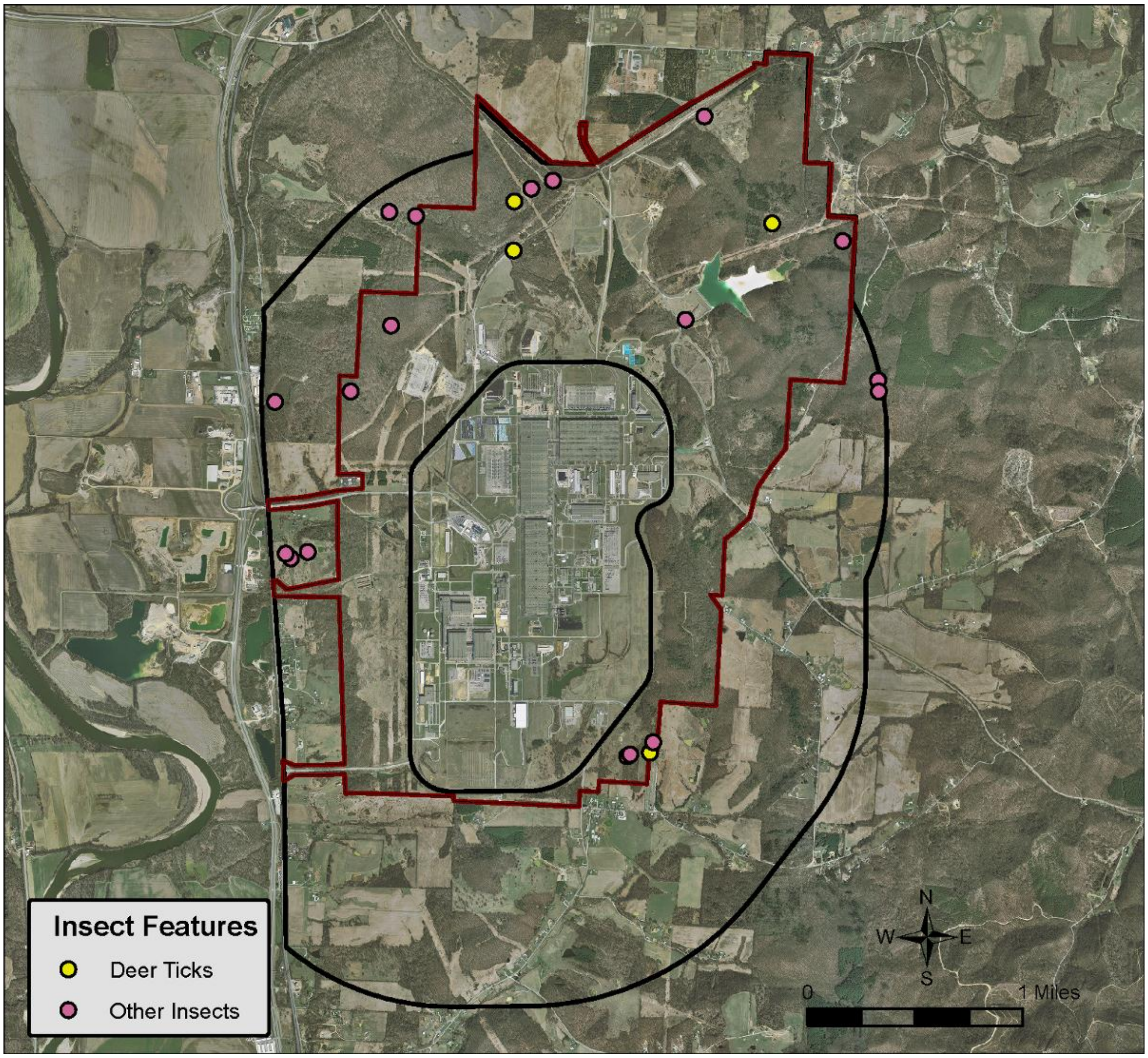

Figure D.12 Map of Observed Insect Features

Figure D.13 Hercules beetle

Figure D.14 Bee-like robber fly

Figure D.15 Protean shieldback katydid nymph

Figure D.16 Cluster of deer tick nymphs captured from clothing

D.2.4 Mammals

Mammals were not frequently encountered during this survey; however evidence of them was common among nearly all habitat types (Figure D.17). While eastern chipmunks (*Tamias striatus*), eastern gray squirrels (*Sciurus carolinensis*), and white-tailed deer (*Odocoileus virginianus*) were often observed performing their normal routines, many mammal species left behind only clues of their presence. American beaver left unmistakable evidence of their occupation of several locations in the study area. Chewed stumps, fallen logs, dragged tree tops, lodges, slides, and dams were observed where the beaver occurred such as the south shore of the X-611B sludge pond, the Little Beaver Creek (Figure D.18) east of the X-734 sanitary landfill, and within the X-2230M holding pond. Among the other mammals that left behind ample evidence to determine their presence include the coyote (*Canis latrans*) (Figure D.19), striped skunk (*Mephitis mephitis*), and the Virginia Opossum (*Didephis virginiana*) (Figure D.20).

White-tailed deer were probably the most commonly observed animal encountered throughout the entire study area and project period. White-tailed deer exist in dense populations within the study area. Just as they are known to pose a threat by hosting deer ticks, they have been reported to impose serious safety hazards to motorists as well. Apart from sighting data, evidence of their behavior was recorded also such as heavy trails, recent beds, fresh scat, buck rubs and scrapes, vegetation browse lines, tracks, as well as bones and corpses. Of particular interest to this study was the impact deer have on the natural vegetation by browsing. Species that are unpalatable to deer, such as *Ageratina altissima* and *Hackelia virginiana*, are often left to grow in place of the many palatable species in which deer have eaten away. These species can be used to indicate areas where deer population are heavy and places that deer may frequent for shelter (Augustine and Jordan, 1998). Figure D.21 illustrates the study plots where these species have been found scaled by their relative importance value within the plot. Note that dominance of these species most often occurs in plots near a major habitat edge, disturbed areas, and open-field food sources. These species are likely correlated spatially with road strikes and could be used to determine the habit of the resident deer population.

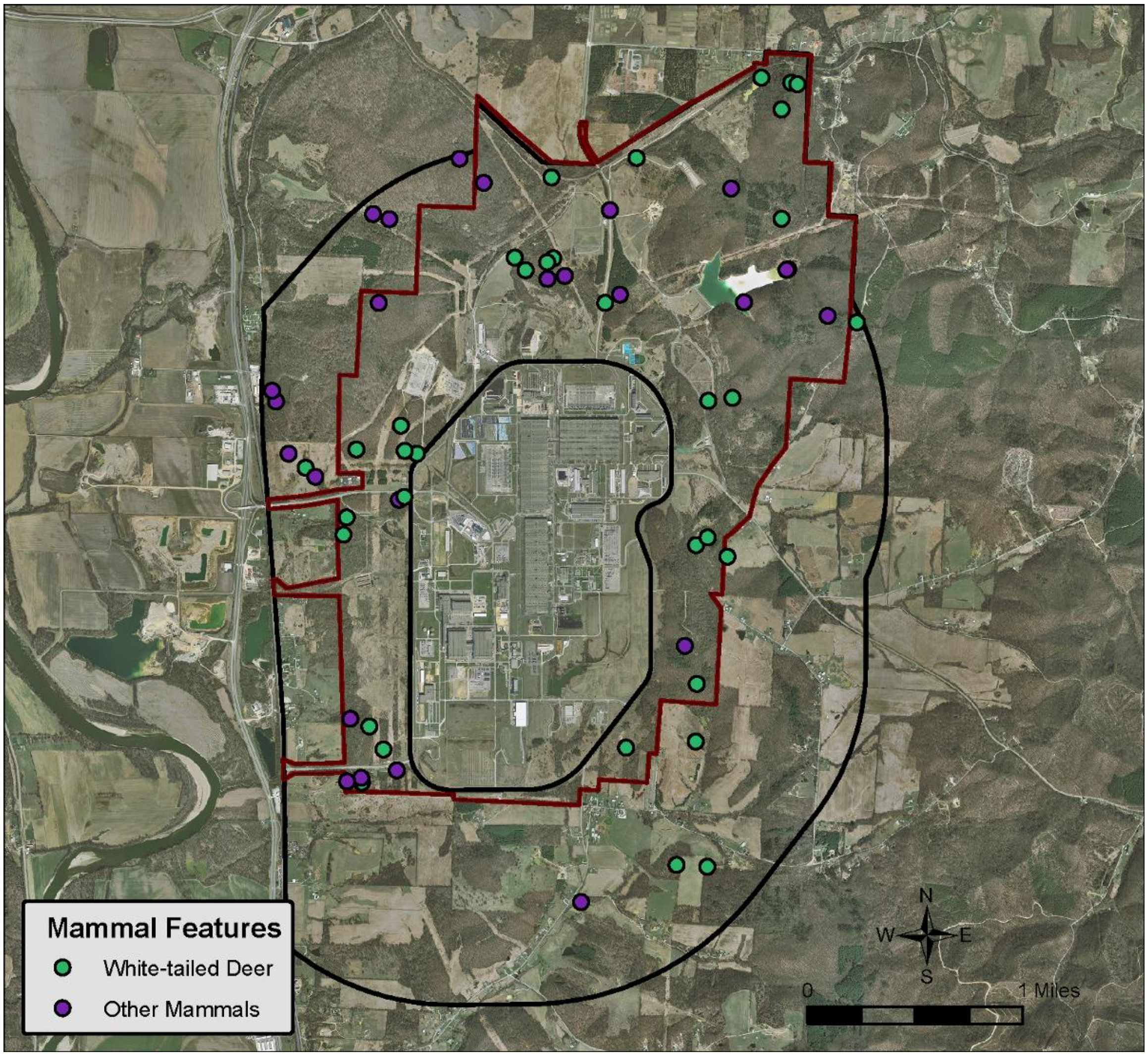

Figure D.17 Map of Observed Mammal Features

Figure D.18 Beaver Dam in Little Beaver Creek

Figure D.19 Pair of coyotes near north entrance

Figure D.20 Tracks of Virginia opossum

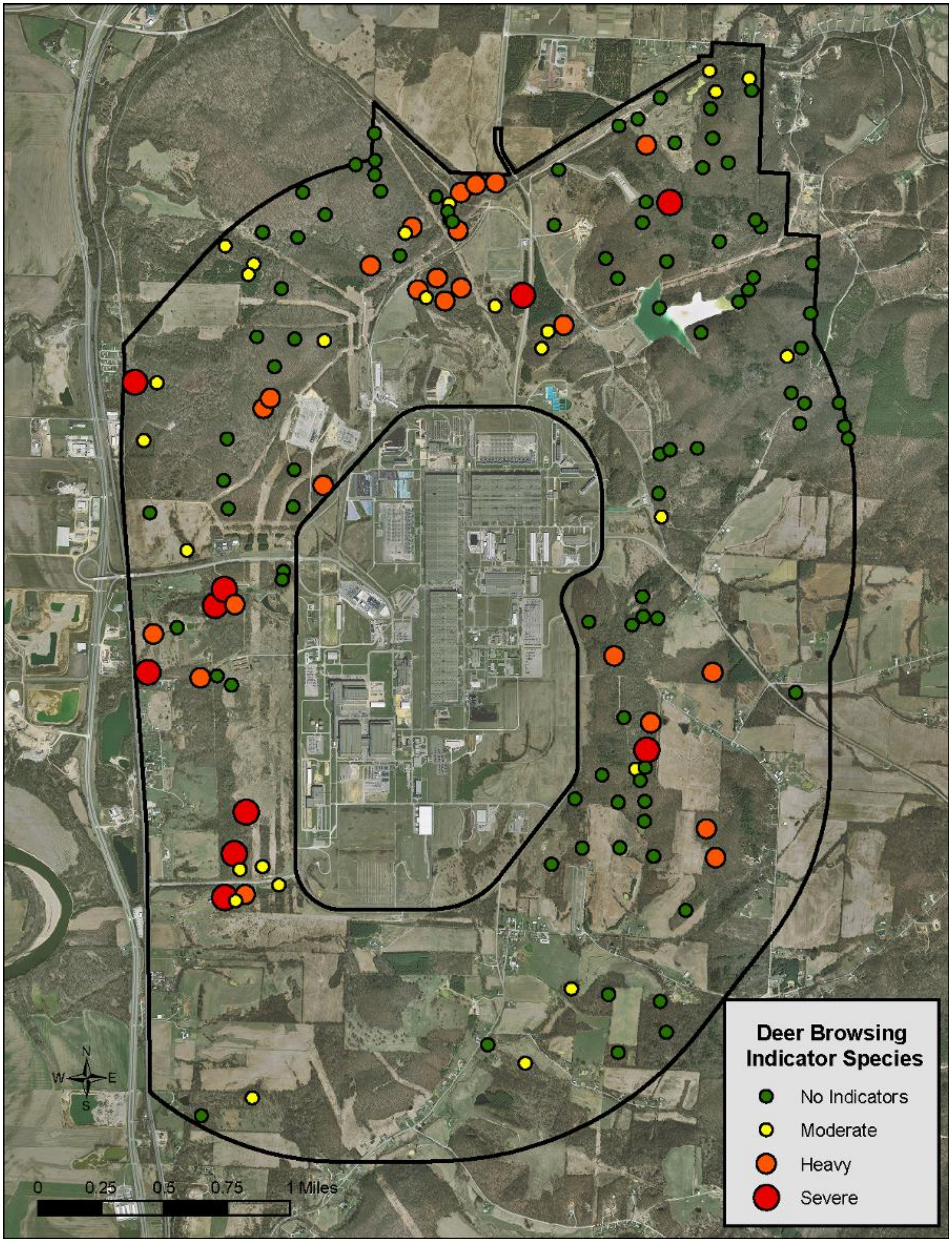

Figure D.21 Map of Sample Sites Colored by Deer Browsing Indicator Species

Appendix E Sample Field Data Sheets

Table E.1 Sample Field Data Sheets

PORTS Vegetation Sample Data Sheet						Sample ID:		
Date:		Time:		Temp °F:		Weather Cond.		
Deg Slope:		Deg Aspect :		%Canopy Cov		Canopy Ht (ft)		
Dominant Canopy Stratum:		Tree	Sapling	Shrub	Herb	Graminoid	Liana	
Trees and Saplings (in)		Woody Stems > 1"DBH and > 4 feet height. Entire Plot						
Species	**DBH**	**Species**	**DBH**	**Species**	**DBH**	**Species**	**DBH**	
Woody Age		Sample cores and stems collected in field. Counts to be completed in lab.						
Species	**Diameter (in)**	**Ring Count**	**Core or Sect**	**Species**	**Diameter (in)**	**Ring Count**	**Core or Sect**	
Species	**Diameter (in)**	**Ring Count**	**Core or Sect**	**Species**	**Diameter (in)**	**Ring Count**	**Core or Sect**	
Shrubs (in)		Woody Stems < 1" DBH and < 4' Height by basal Diameter Class						
v				**1/4's Sampled**	**NW NE SW SE or ALL**			
Species	**0.25**	**0.5**	**0.75**	**1**	**1.25**	**1.5**	**1.75**	**2**
Woody Vines (in)		Woody lianas climbing or creeping						
Stem count by diam. class; inches diam. at base; by Box Count				**1/4's Sampled**	**NW NE SW SE or ALL**			
Species	**0.25**	**0.5**	**0.75**	**1**	**1.25**	**1.5**	**1.75**	**2**

PORTS Vegetation Sample Data Sheet (back)						Sample ID:	
Vascular Herbs		Herbaceous species and percent ground cover in a 1-meter plot				% Total G.Cover	
Northwest %Cov:		**Northeast** %Cov:		**Southeast** %Cov:		**Southwest** %Cov:	
Species	**% Cover**	**Species**	**% Cover**	**Species**	**% Cover**	**Species**	**% Cover**

Landform, Substrate and Soil Characteristics				Circle all that apply			
Surface Shape:	Planer	Convex	Concave	Depressional	Benched	Sigmoid	
Position:	Hill Crest	Ridge Top	Hill Slope	Toe	Valley	Upper Flood	Lower Flood
Duff & Litter Depth (inches):			**Organic Layer Depth (inches):**			**D&L % Cover:**	
Woody Debris % Cover:			**Debris Scale:**	>12"	6-12"	1-5"	=/>1"
Soil Characteristics to 12 Inches							
Horizon	**Depth**	**Matrix Color**	**Mottle Color**	**Class**	**Grade**	**Type**	**Consistence**
Other Surface/subsurface Features:		Gravelly	Stony/Platy	Residual	Colluvial	Alluvial	Aeolian
Hydrologic Characteristics			Circle all that apply				
Drainage:	Very Poorly	Poorly	Mod-Poorly	Mod-Well	Well	Excessively well	
Water Presence:	Flowing	Ponded	Saturated	Within Soil Hole	Water-born Debris	Staining	Dom. Hydrophytes
Antecedent Moisture Conditions:		Raining	Recent Flood	<24 hrs.	<72hrs	>7 Days	Drought
Other Hydrologic Observations:							
Habitat Observations			Count, estimate or comment				
Number of open holes and cavities in standing woody vegetation					None Few Some Many or	Count:	
Presence of loose attached bark on mature trees such as hickory and sycamore					Yes No		
Rocky holes, cracks, overhangs and/or crevices				Yes No			
Light soil with burrows observed				Yes No			
Raptor perches				Yes No			
Other Habitat Observations:							