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

Authors:

Robert Wiley, Gary Conley, Steven Porter, David Simon, Natalie Kruse, Robert Eichenberg, and Jennifer Bowman

Sponsored by Ohio University's PORTSfuture Project

The PORTSfuture project is funded by a grant from the U.S. Department of Energy Office of Environmental Management Portsmouth/Paducah Project Office

PORTSFUTURE

IMAGINING THE OPPORTUNITIES, GATHERING YOUR IDEAS

THE FACILITY AT PIKETON, OHIO

Table of Contents

List of Tables

List of Figures

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

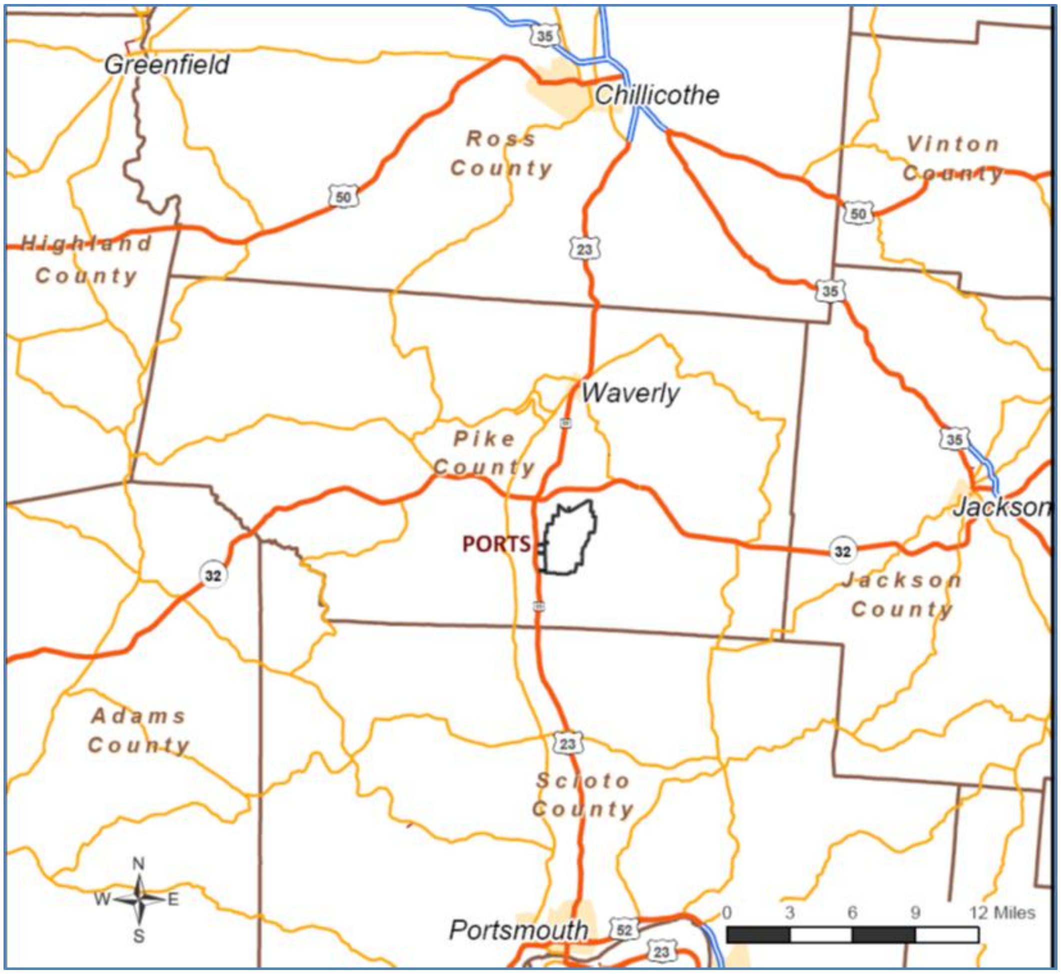


Figure 1.2 The location of PORTS in south central Ohio / Pike County

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).

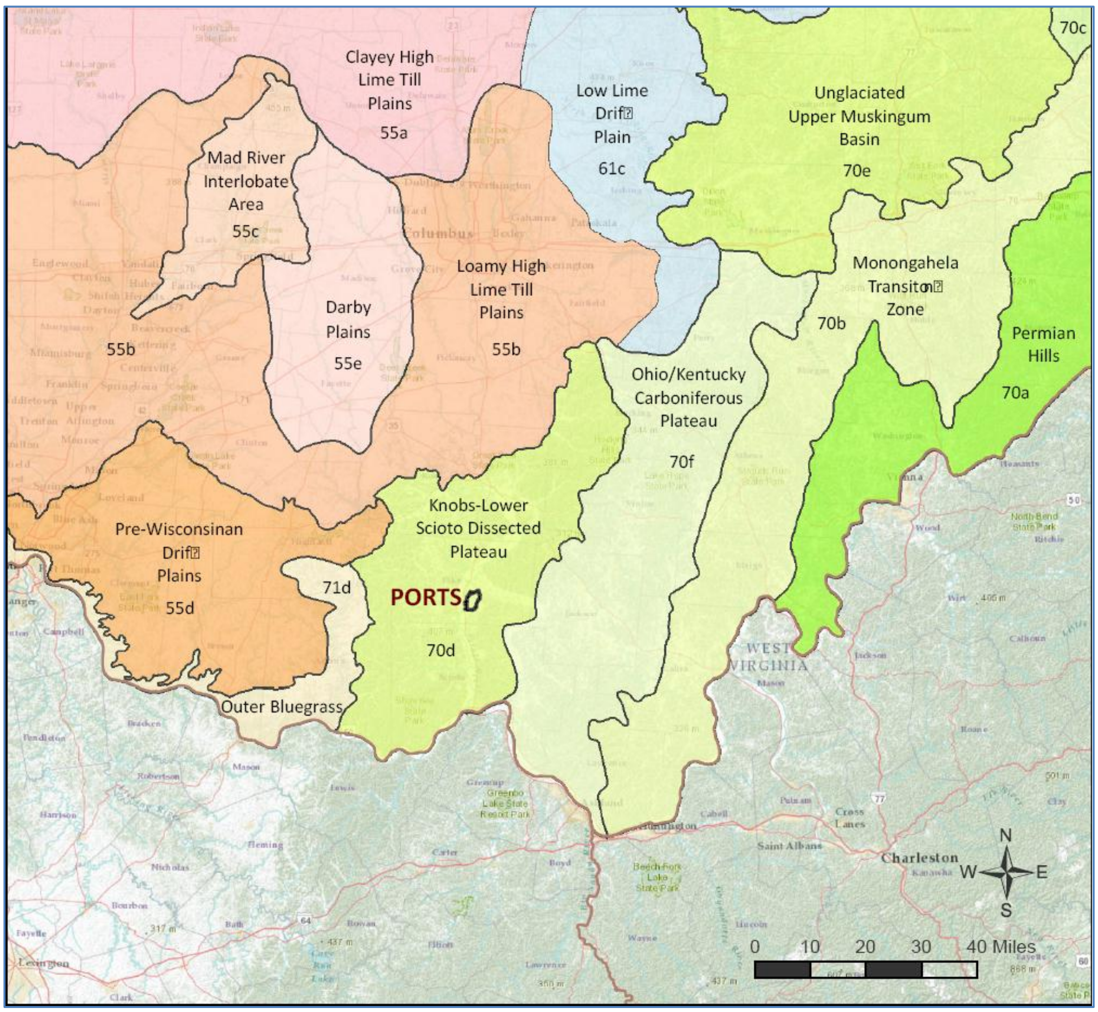


Figure 1.3 The physiographic ecoregions of southern Ohio

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.

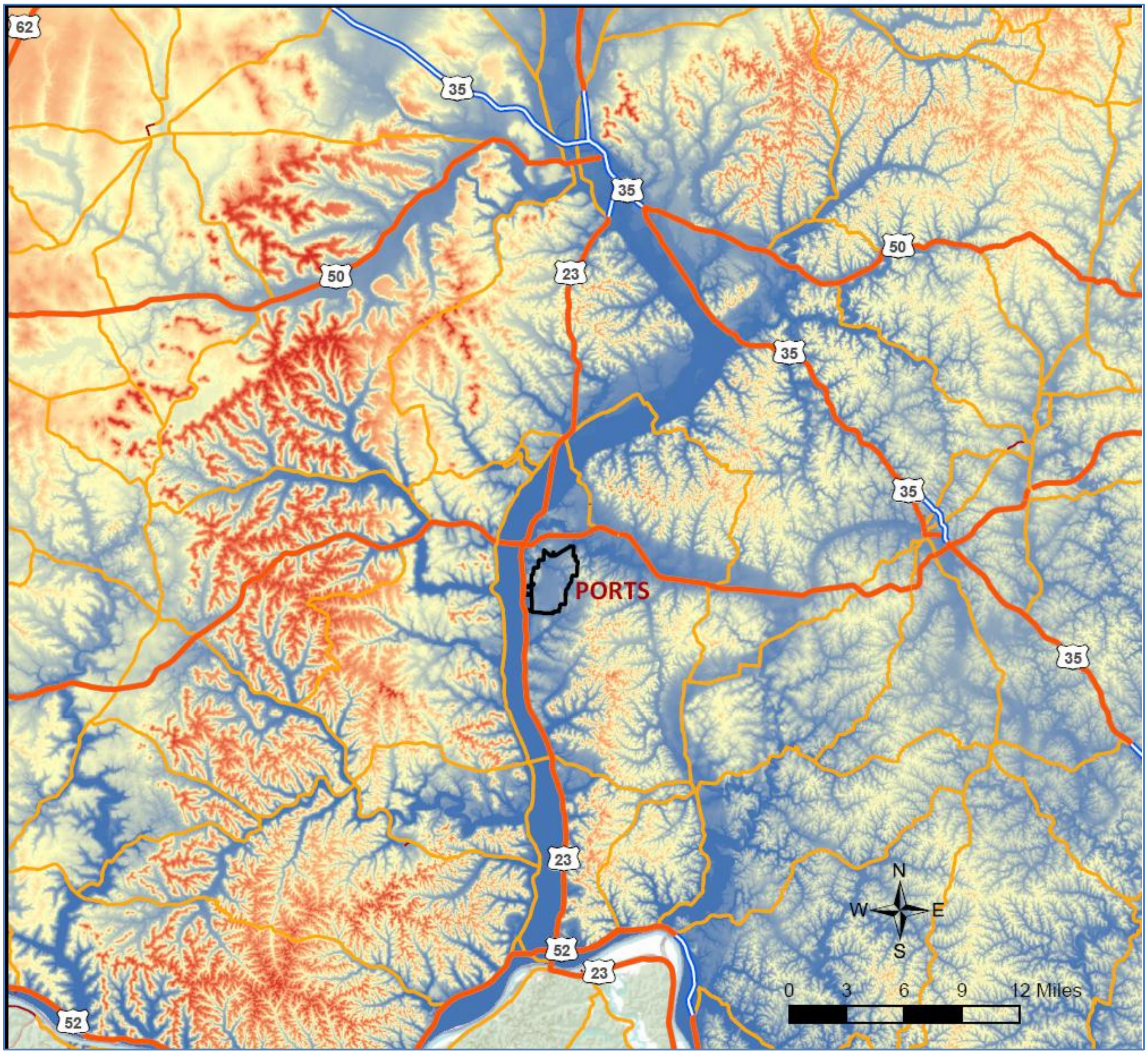


Figure 1.4 Digital elevation model (DEM) of the vicinity of PORTS

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.

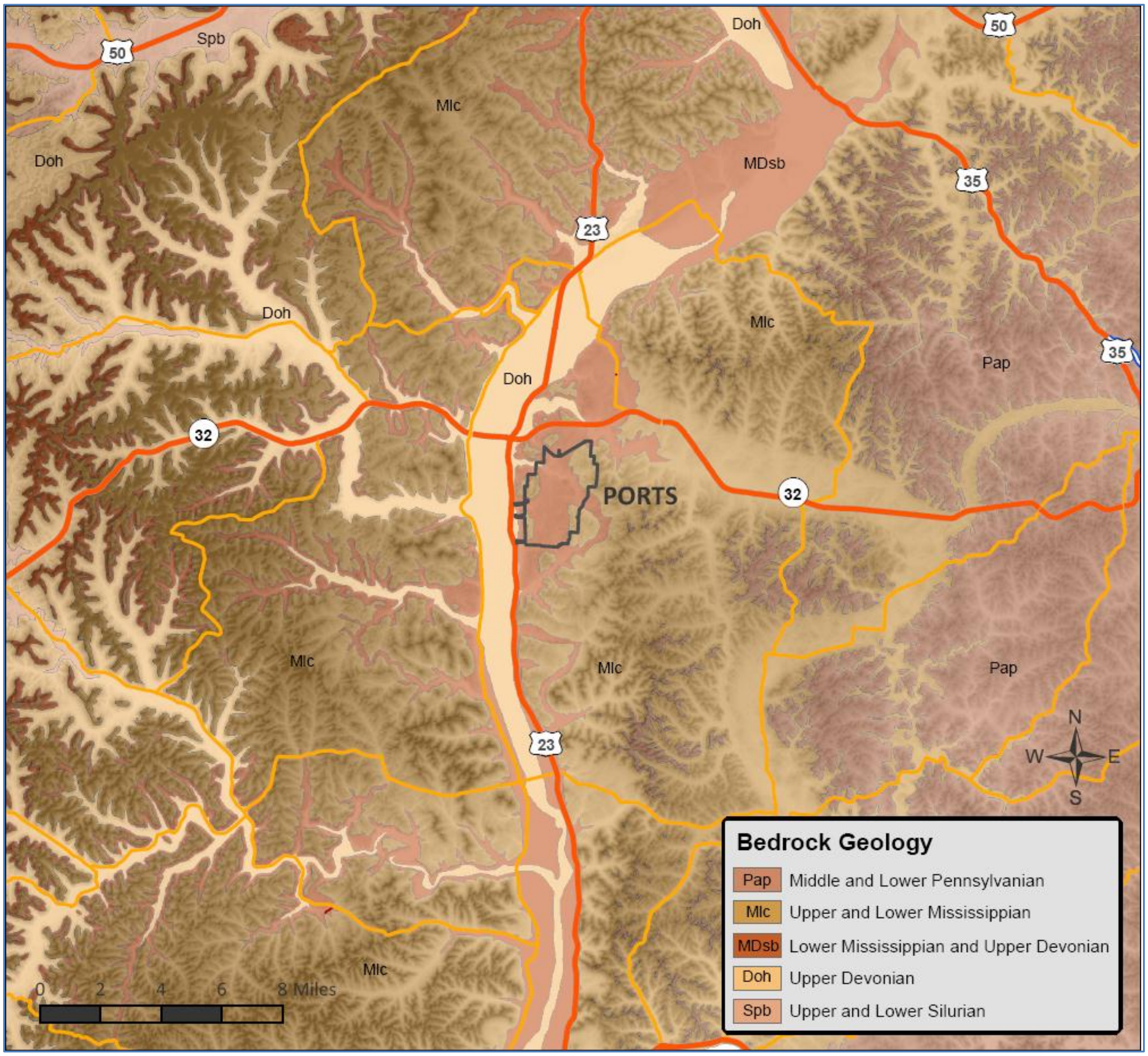


Figure 1.5 The bedrock geology of the PORTS region (Slucher, 2006)

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.

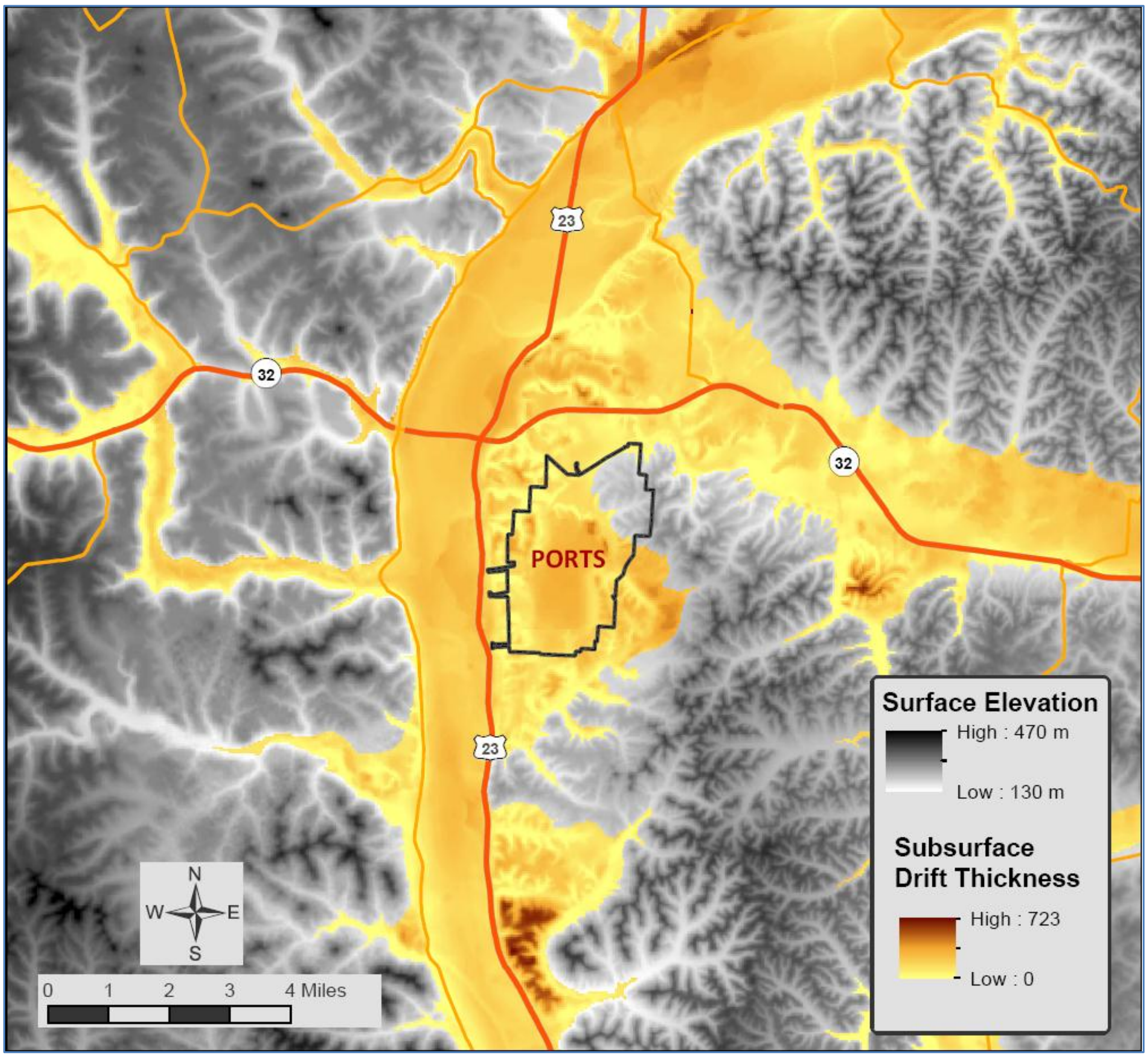


Figure 1.6 The drift thickness of glacial sediments from the surface in the PORTS region (Powers, 2004)

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.

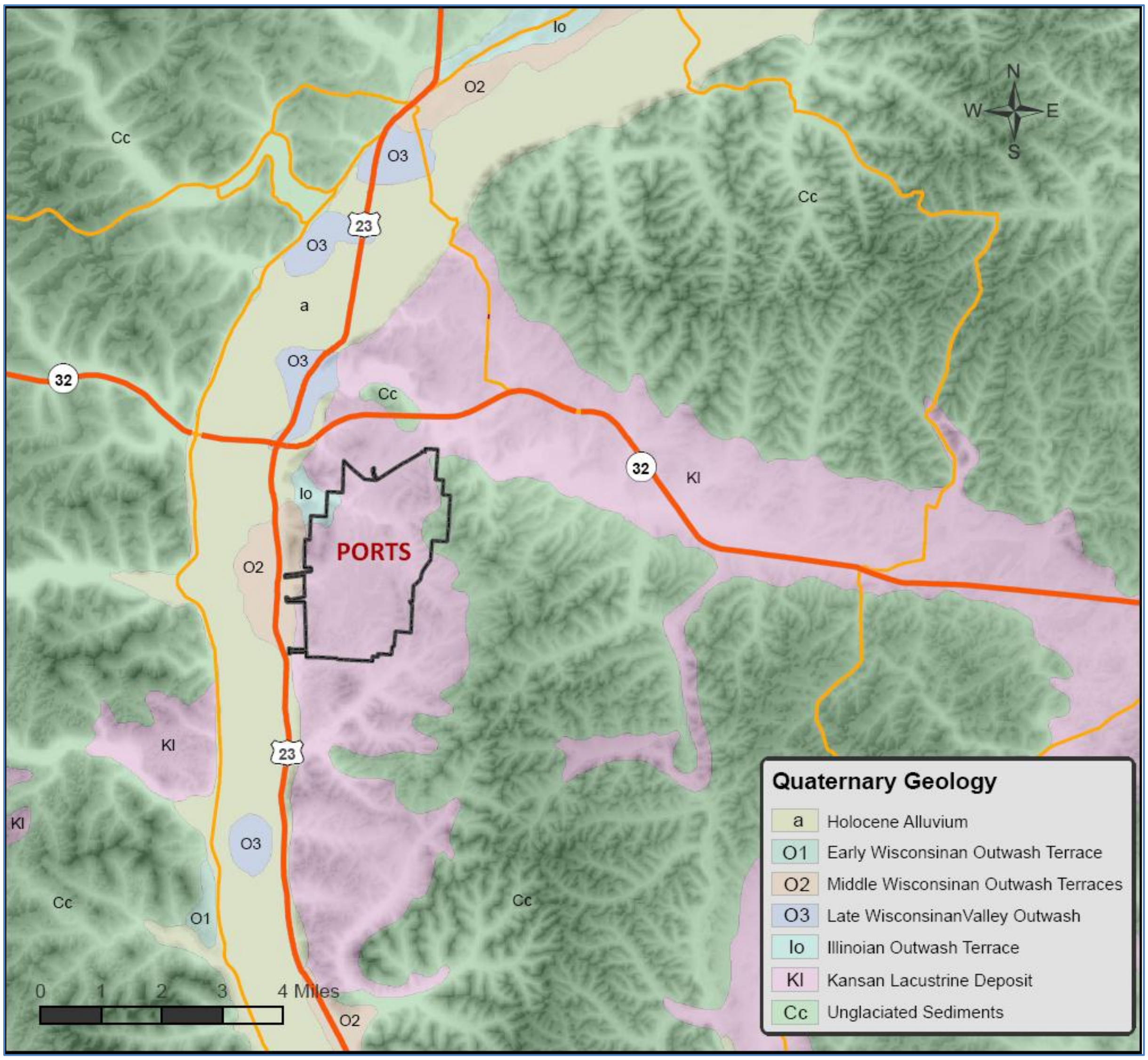


Figure 1.7 The classification of quaternary geology in the PORTS region (Pavey, 1999)

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.

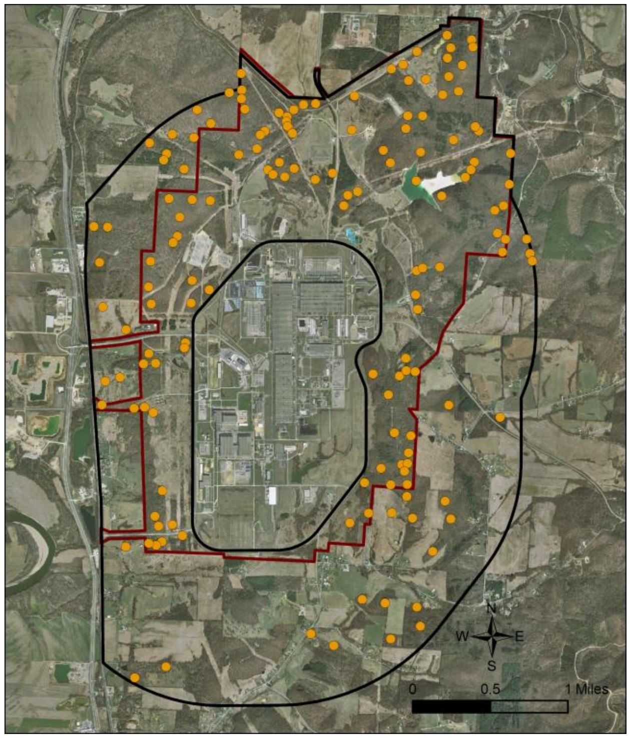


Figure 2.1 Sampling plot locations within the study area

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.

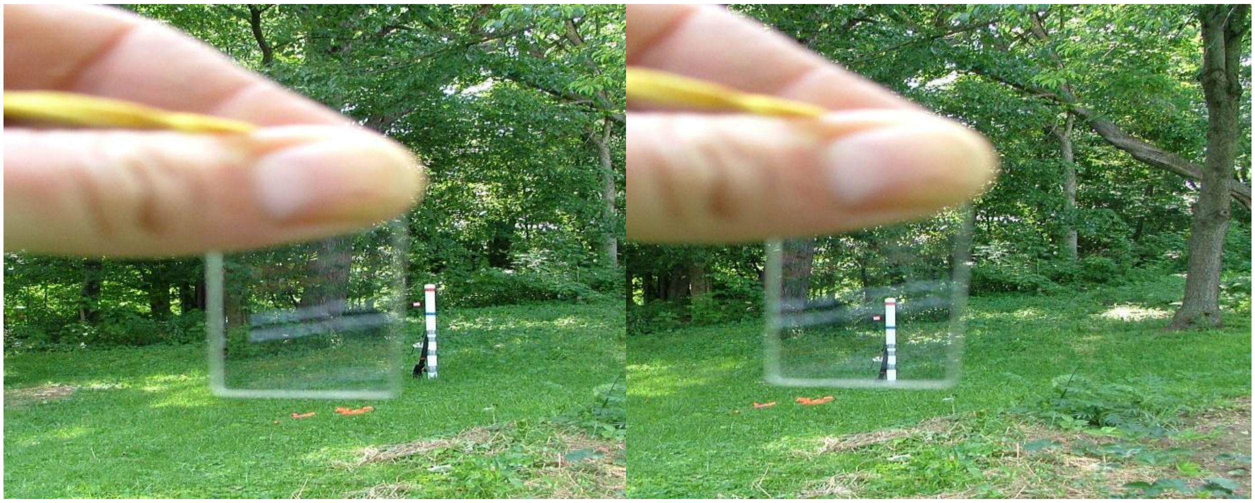


Figure 2.3 Forester's prism used to set up plot perimeter

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.

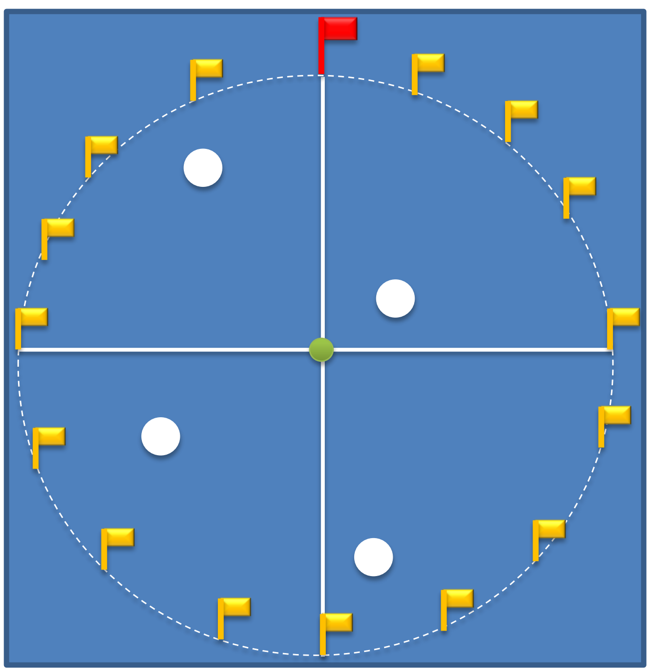


Figure 2.4 Plot set-up configuration

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 $3/16^{th}$ 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:

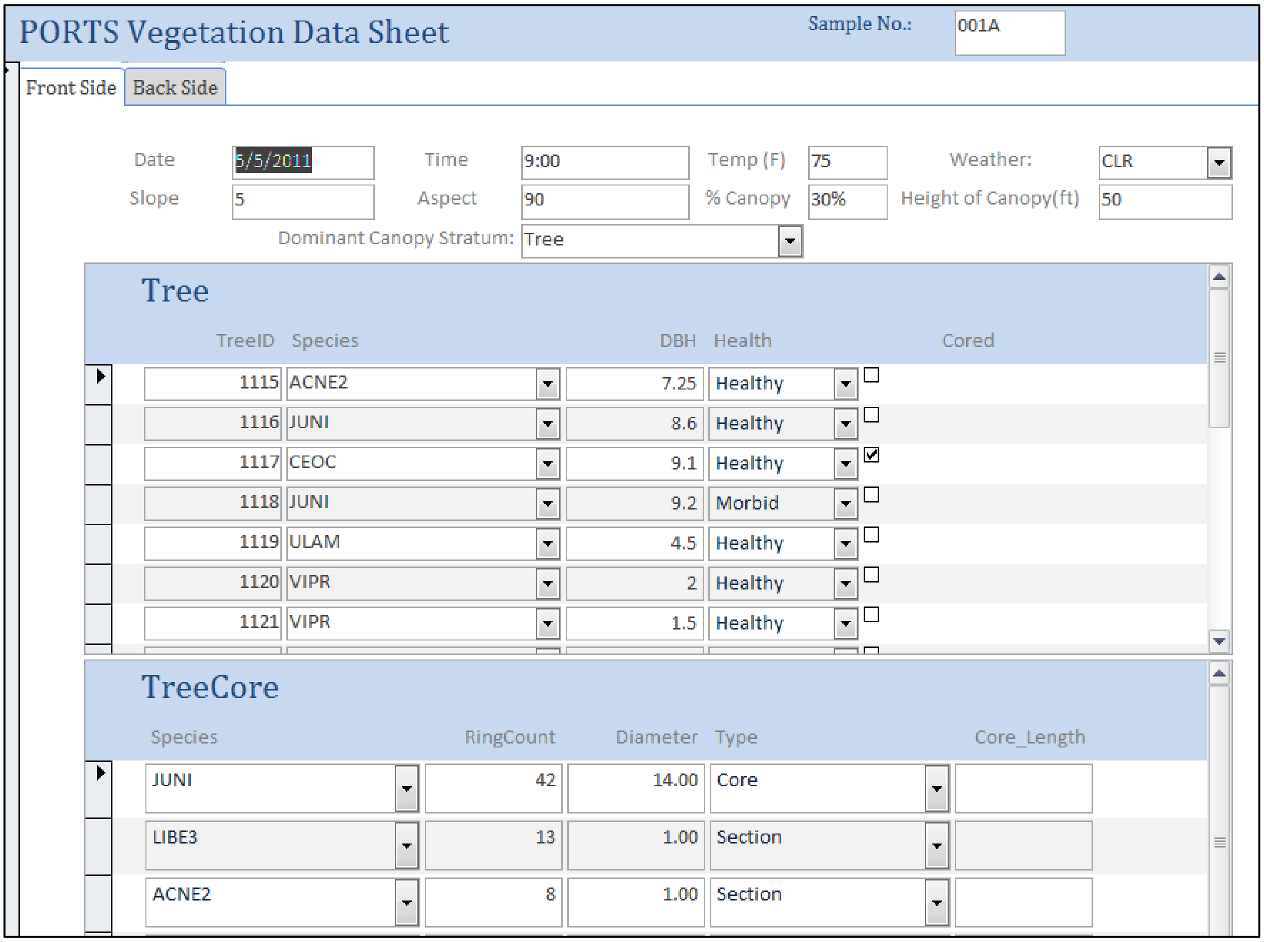
Plotid: The alphanumeric ID of the related vegetation plot

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


PORTS Vegetation Data Sheet

Sample No.: 001A

Front Side | Back Side

Date 5/5/2011 Time 9:00 Temp (F) 75 Weather: CLR

Slope 5 Aspect 90 % Canopy 30% Height of Canopy(ft) 50

Dominant Canopy Stratum: Tree

Tree

TreeID	Species	DBH	Health	Cored
1115	ACNE2	7.25	Healthy	☐
1116	JUNI	8.6	Healthy	☐
1117	CEOC	9.1	Healthy	☑
1118	JUNI	9.2	Morbid	☐
1119	ULAM	4.5	Healthy	☐
1120	VIPR	2	Healthy	☐
1121	VIPR	1.5	Healthy	☐

TreeCore

Species	RingCount	Diameter	Type	Core_Length
JUNI	42	14.00	Core	
LIBE3	13	1.00	Section	
ACNE2	8	1.00	Section	

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.

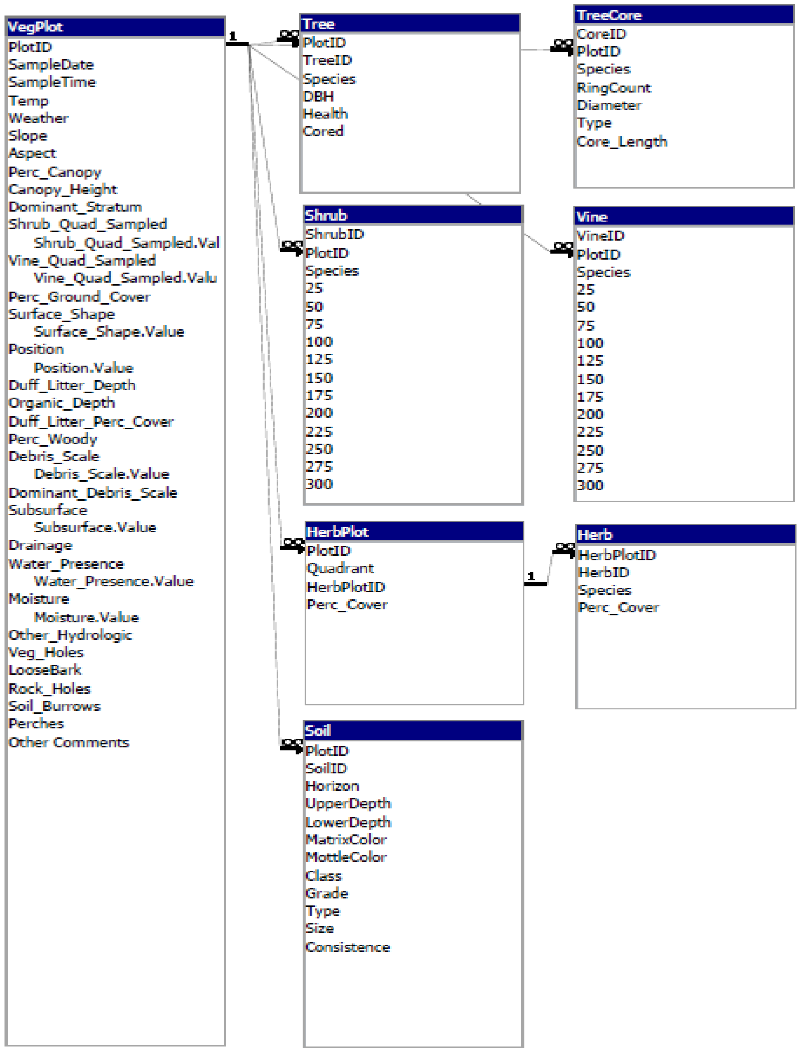


Figure 2.11 Diagram of table relationships

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