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

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

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

2.5.4.1 Importance Value Weighted Averages

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

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

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

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

2.5.4.2 Individual Species Count

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

2.5.4.3 Total Frequency

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

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

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

2.5.3.4 Relative Frequency

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

2.5.4.5 Total Woody Dominance

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

The equation to calculate basal area is:

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

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

2.5.4.6 Relative Woody Dominance

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

2.5.4.7 Total Herbaceous Dominance

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

2.5.4.8 Relative Herbaceous Dominance

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

2.5.5 Wetland Prevalence Index

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

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

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

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

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

Table 2.4 Wetland Indicator Status Categories

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

2.5.6 Nativity, Native Status Index

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

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

Table 2.5 Native Status Scale

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

2.5.7 Floristic Qualitative Assessment Index and the Coefficient of Conservatism.

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

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

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

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

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

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

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

2.5.8 Species Diversity

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

2.5.8.1 Simpson's Heterogeneity

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

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

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

2.5.8.2 Shannon's Diversity Index

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

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

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

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

2.5.9 Herbaceous Ground Cover Density

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

2.5.10 Woody Stem Density

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

2.5.11 Average Woody Diameter

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

2.5.12 Dominant Life Form

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

Table 2.7 Life Form Index

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

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

2.5.13 Woody Vegetation Health

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

2.5.14 Reproduction

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

3.0 DISCUSSION OF FINDINGS

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

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

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

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

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

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

3.1 Plant Species Statistics

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

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

Table 3.2 Species Native Status Summary

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

Table 3.3 Wetland Status Count by Species

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

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

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

Table 3.5 Species Count by Growth Form

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

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

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

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

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

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

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

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

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

3.2 Dominant Stratum

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

3.3 Dominant Canopy Species

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

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

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

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

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

Table 3.9 Tree Canopy Habitat Species and Importance Values

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

3.4 Age of Stand

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

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

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

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

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

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

3.5 Site Occupation: Tree Size and Biomass

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

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

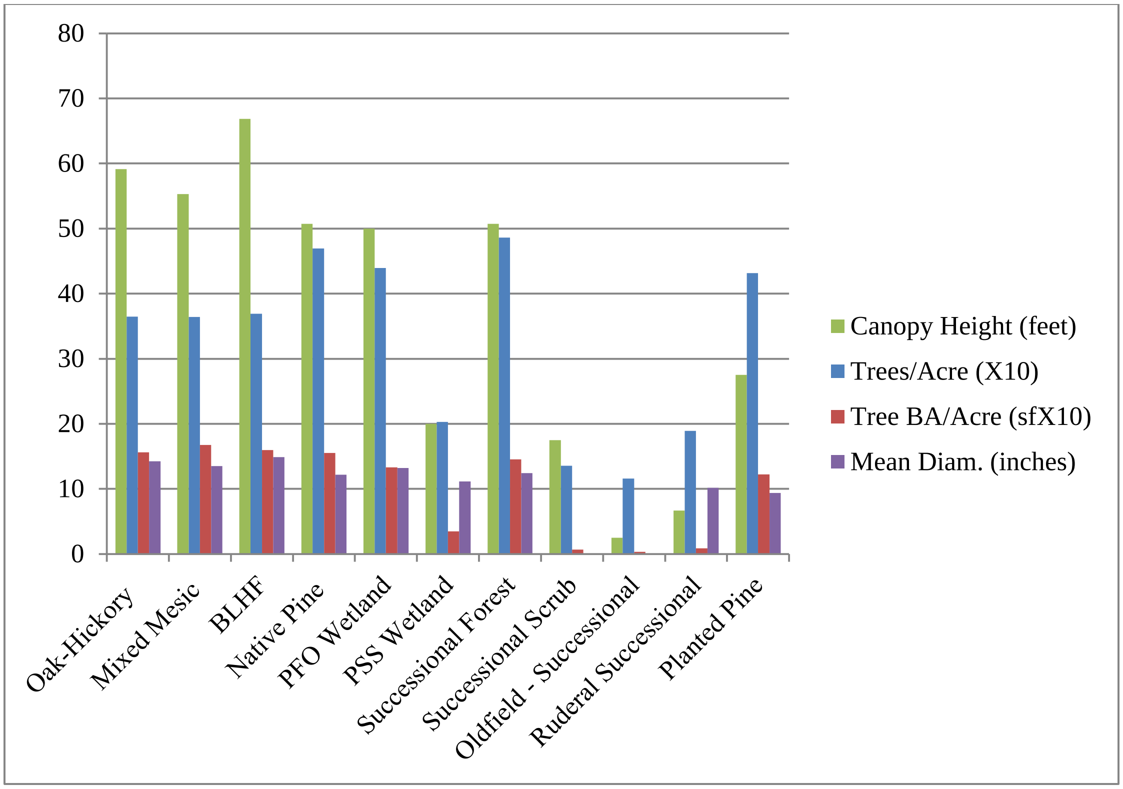

Figure 3.1 Site Occupation and Site Characteristics for PORTS Area Forests

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

Table 3.11 Tree Biomass Correlation

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

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

3.6 Growth Rate of Woody Vegetation

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

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

3.7 Dominant Shrubs and Saplings

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

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

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

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

3.8 Dominant Woody Vines

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

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

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

3.9 Dominant Herbaceous Stratum

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

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

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

3.10 Measures of Diversity

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

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

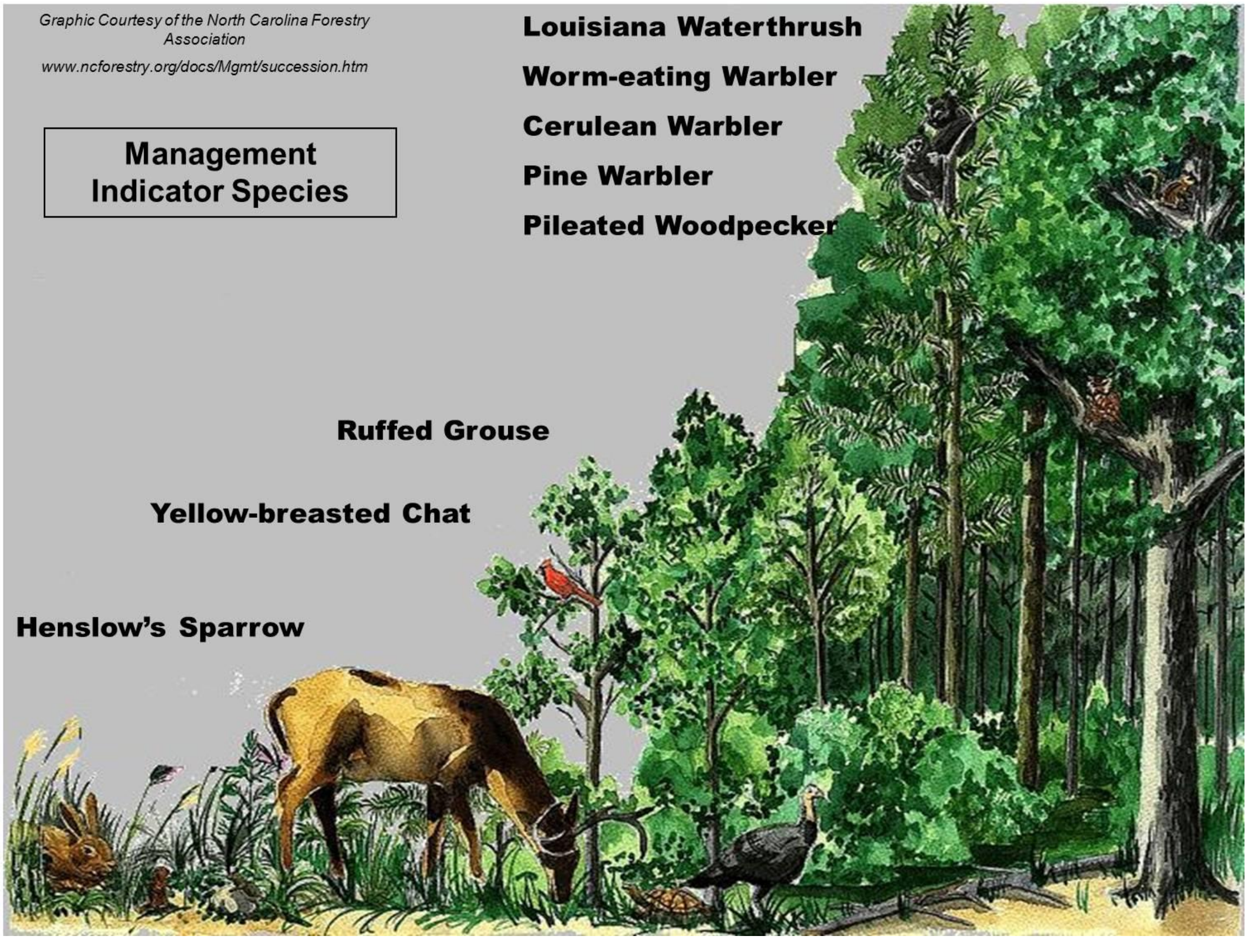

Figure 3.2 Example of changing habitats and species accumulation

3.11 Wetland Index

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

3.12 Nativity Index

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

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

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

Table 3.15 Nativity Indices by Strata

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

3.13 Coefficient of Conservatism Value and Floristic Qualitative Assessment Index

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

4.0 Example Application of Habitat Mapping

4.1 Introduction

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

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

4.2 Example Application: Habitat Suitability Index

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

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

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

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

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

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

4.2.1 Methods

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

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

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

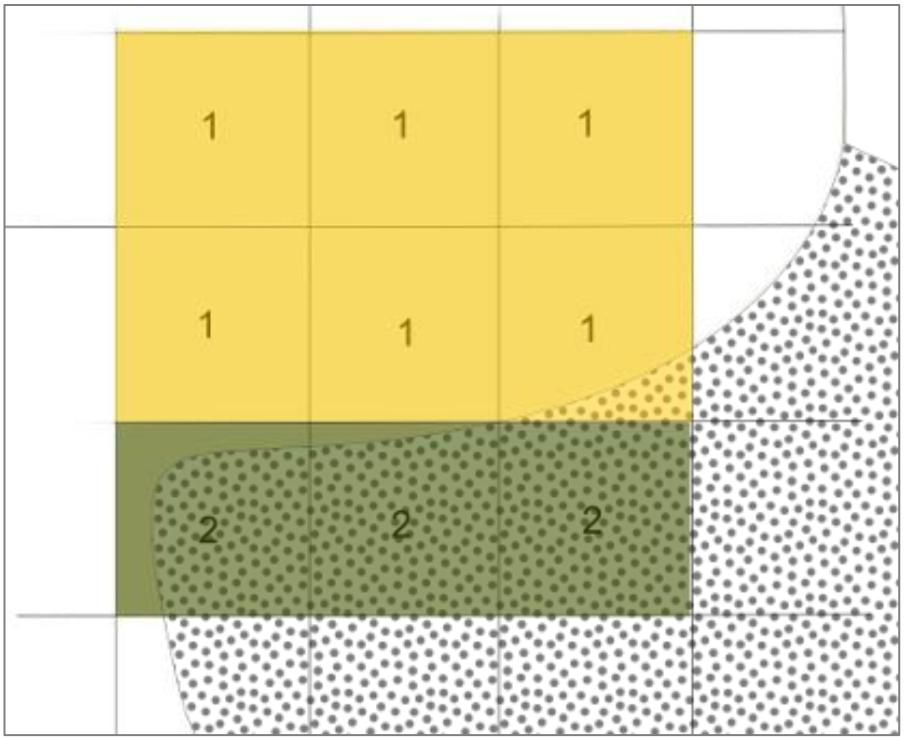

Figure 4.1 Example of grid sampling

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

4.2.1.1 Input Data

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

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

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

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

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

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

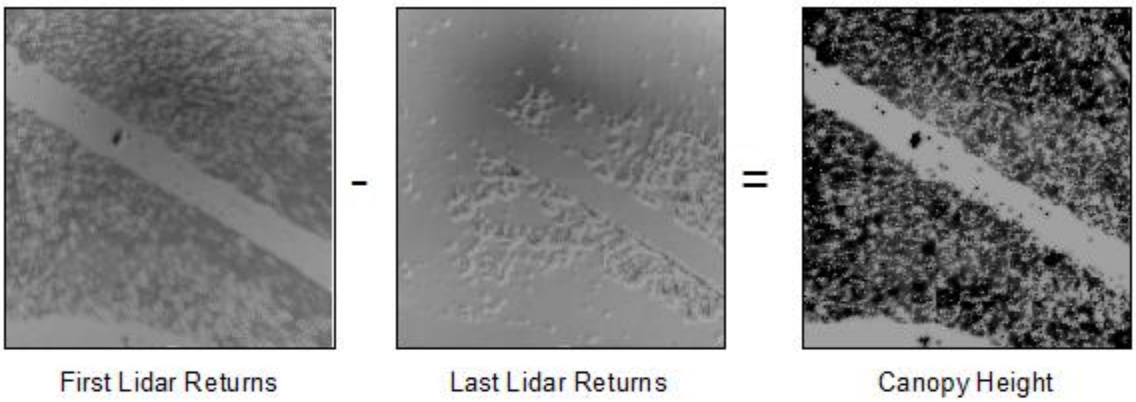

Figure 4.2 Example of height derivation from lidar digital elevation models

4.2.1.2 Ecological Land Type (ELT)

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

4.2.1.3 Forest Stand Age

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

4.2.1.4 Land Cover Type

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

Table 4.1 ELT classification and description

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

4.2.2 Sources of Error or Uncertainty

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

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

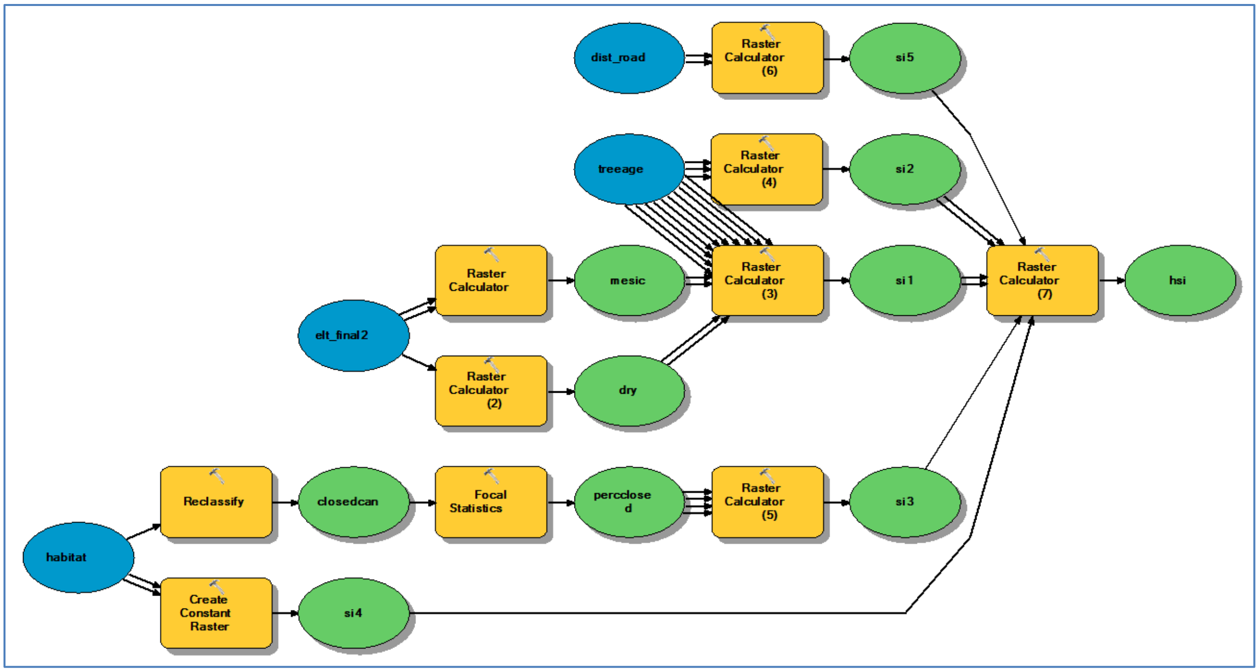

Figure 4.3 Example of Model Builder

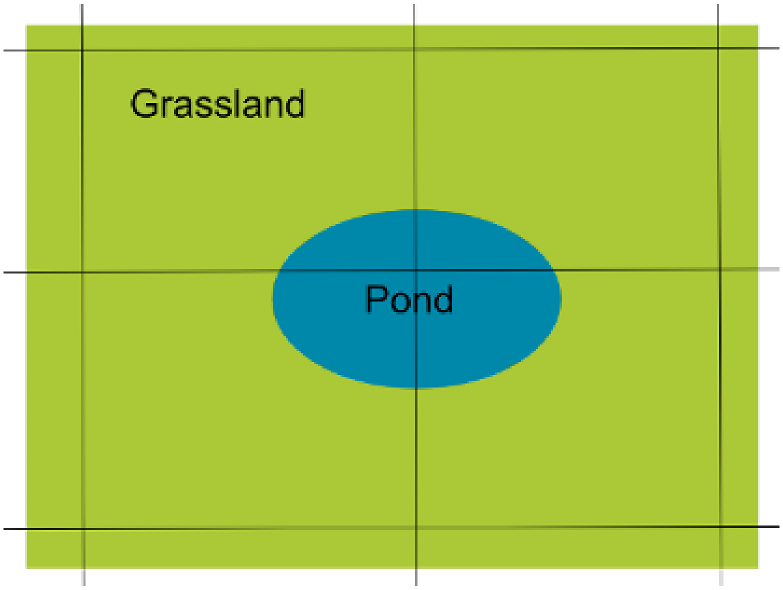

Figure 4.4 Example of sub-grid phenomena

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

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

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

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

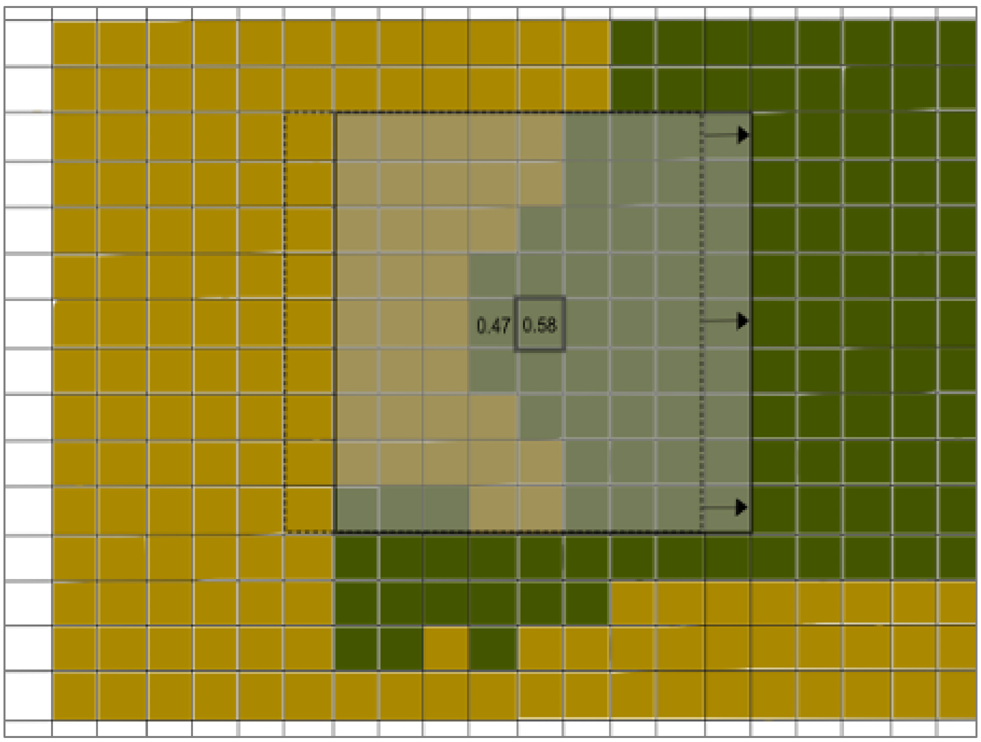

Figure 4.5 Example of neighborhood process evaluating the percent forest (green cells) of a cell from its neighborhood (shaded region)

4.3 Example HSIs

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

4.3.1 Indiana Bat (Myotis sodalis)

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

4.3.1.1 Suitability Indexes (SI)

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

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

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

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

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

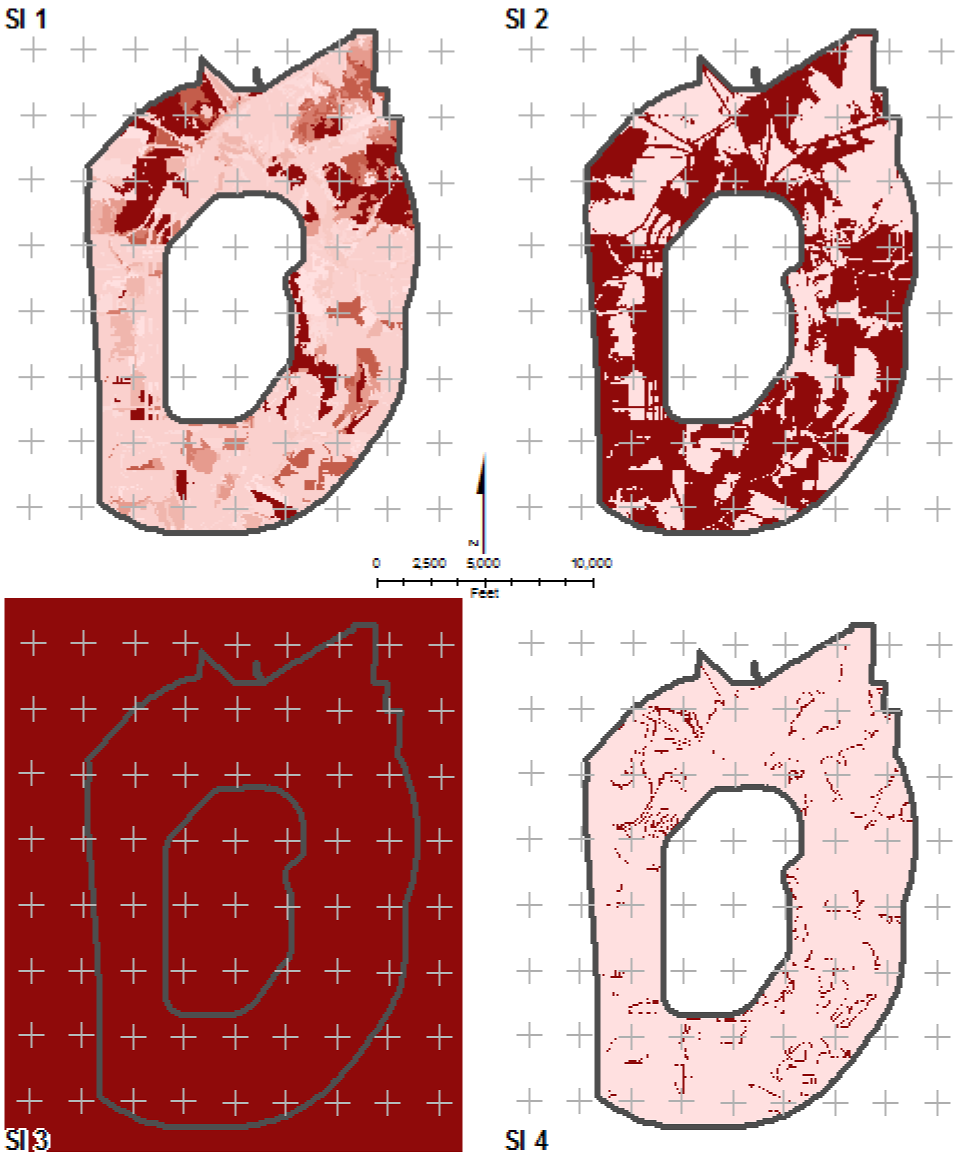

Figure 4.6 Indiana Bat SIs, Darker Shading Denotes Higher Suitability

4.3.1.2 Habitat Suitability Index

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

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

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

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

Figure 4.7 Indiana Bat HSI, Darker Shading Denotes Higher Suitability

4.3.2 Timber Rattlesnake (Crotalus horridus)

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

4.3.2.1 Suitability Indexes (SI)

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

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

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

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

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

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

4.3.2.2 Habitat Suitability Index

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

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

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

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

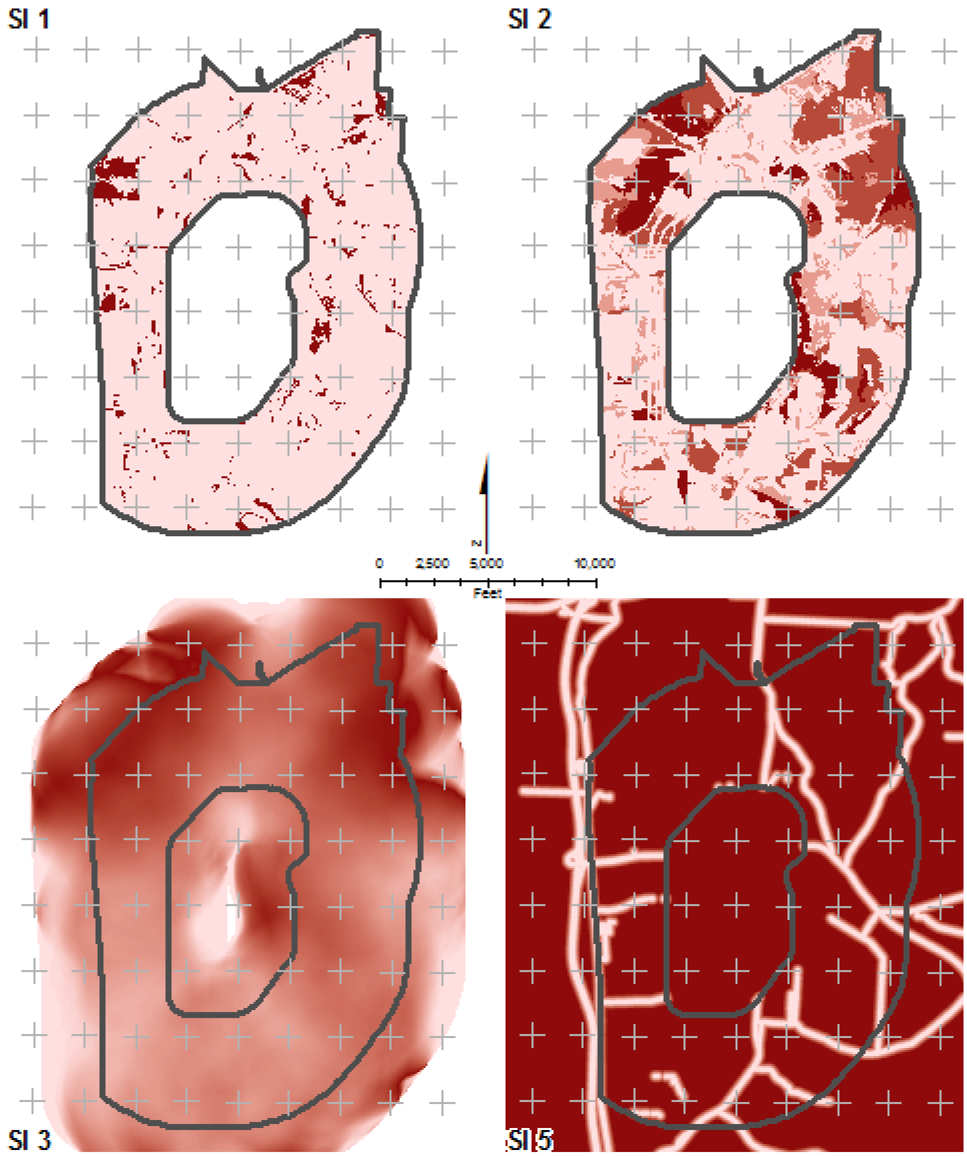

Figure 4.8 Timber Rattlesnake SIs, Darker Shading Denotes Higher Suitability

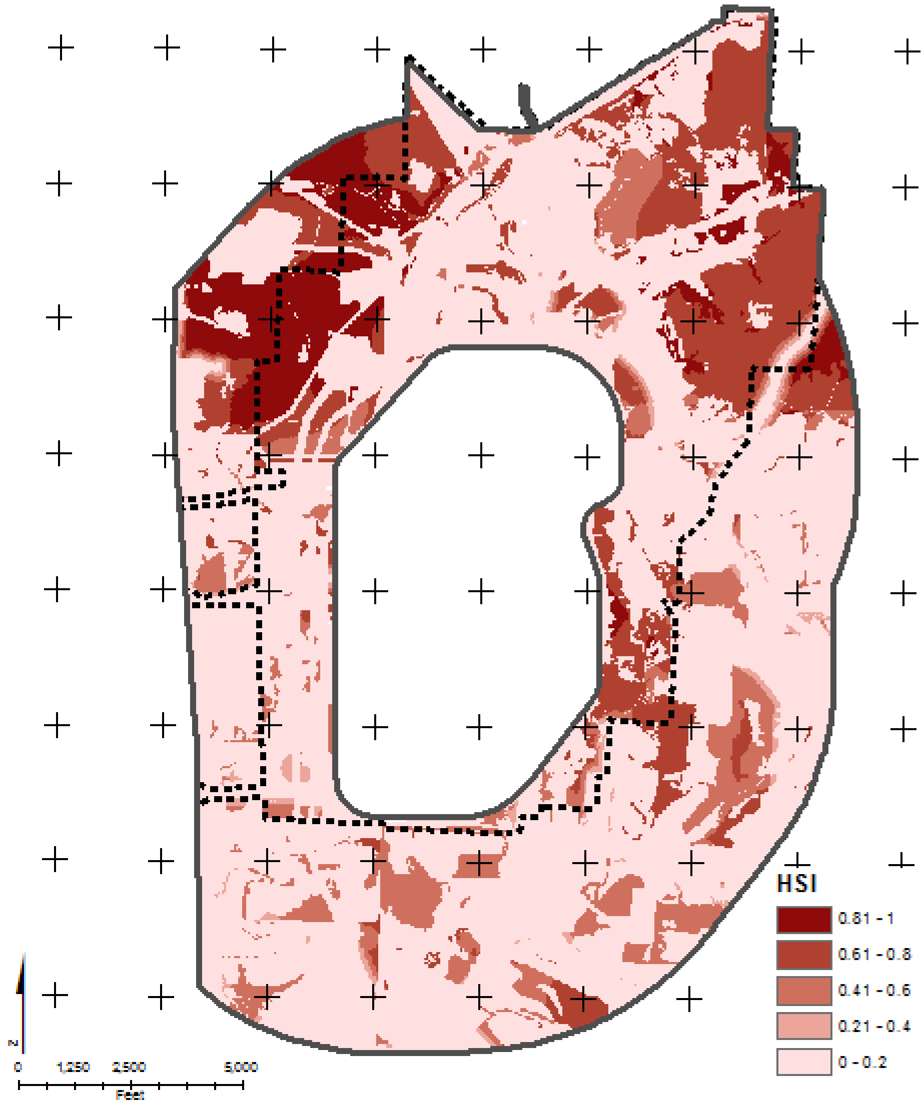

Figure 4.9 Timber Rattlesnake HSI, Darker Shading Denotes Higher Suitability

4.4 Recommendations for Future Analysis

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

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

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Appendix A Habitat Map

Appendix B Summary of Public Involvement

Summary of public involvement

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

Appendix C List of Plant Species

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

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

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

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

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