Department of Planning Design and Natural Resources
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Plant Community Assessment Program (PCAP) 2013 preliminary report

Cleveland Metroparks Technical Report 2013/NR-XX

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Table of Contents

Executive Summary 5
Background: 7
Table 1. Expected sampling effort and plot locations for one 5-year cycle of vegetation sampling for the Plant Community Assessment Program. 7
Program Summary 9
Experimental Design 11
Figure 1. Representative 10-module plot layout indicating location of intensive sampling modules with shaded and open corners indicated 11
Table 2. Reservation codes and number of plots visited and sampled in 2012. 12
Plant Community Characterization 13
Reservation Condition 14
Table 3. Community condition measurements for each minor reservation sampled combined sampling years. 14
Table 4. Community condition measurements for each major reservation sampled. 15
Figure 2. Average and range of VIBI scores for the minor reservations for the combined sample years of 2010-2013. 16
Figure 3. Average and range of VIBI scores for the major reservations samples in 2010-2013 and the combined minor reservations. 17
Table 5 . Proportion of VIBI scores >60 and <30 in the major reservations and the combined minor reservations. 17
Figure 4. Percentage of VIBI scores greater than 60 and less than 30 for the major reservations an the combined minor reservations 18
Plant Community Characterization and Condition 19
Figure 5. Distribution of random plot locations by major plant community types sampled (modified Nature Serve community classification). 27
Figure 6. Categories for classifying sampling plots as LDP 28
Emerald Ash Borer 28
Table 6. The table displays the total number of plots sampled within each reservation, the number of plots with ash trees, and the percentage of plots with ash by reservation. Each reservation includes results from 2010-2013 .. 29
Table 7. 2013 Average size and number of ash trees encountered by species across all reservations. 30
Table 8. Ash tree condition, based on EAB indicator characteristics for each reservation in 2013 31
Deer Browse 32
Table 9. Number of plots in each category for deer browse intensity by reservation 33
Buffer Plots 34
Invasive Plants 36
Table 10. PCAP invasive plant survey based on the total plot occurrence for each targeted invasive species from 2011-2013(298 plots), the 2012-2013 average size class and the average estimated population size (plant count) for 2012-2013. 37

Table 11. Designated size classes (1-5) for surveying the invasive plant population 38
Species Summary 39
Tier System Summary 39
Trails 41
Table 12. Trail type distribution plots had identified trails. Trail types included APT, bridle, and sanctioned as well as unsanctioned (bootleg), deer, and road. 41
Table 13. Encroachment incidents documented during PCAP 2013. 42
Terrestrial VIBI 42
Research Collaborations 46
Appendix 1: Modified U.S. National Vegetation Classification System developed by Nature Serve 50

Executive Summary

Cleveland Metroparks is monitoring terrestrial natural resources through the Plant Community Assessment Program (PCAP). This long-term vegetation monitoring project will report on the composition and existing condition of plant communities in Cleveland Metroparks and identify how these communities change over time.

Four hundred monitoring plots (~100/year * 4 years) will serve as the baseline dataset with repeated sampling events used to evaluate changes in community condition. The fourth sampling cycle was implemented in 2013 and a total of 405 plots have been surveyed and completed. In 2010 in addition to the initial 100 PCAP plots, 8 plots in West Creek Reservation were surveyed as part of the National Science Foundation Urban Long Term Research Area Exploratory project (ULTRA-Ex). The fourth PCAP sampling cycle was completed by three seasonal crews from June 12 to September 4, 2013 with a total of 100 plots surveyed. Thirteen reservations were sampled in 2013 including 6 minor (small) and 7 major reservations. Habitat quality was determined using community assessment tools including a modified Vegetation Index of Biotic Integrity (VIBI) and the floristic quality assessment index (FQAI). Currently under development, this modified VIBI for upland forests eliminates the metric for wetland specialist plants (% hydrophyte) which reduces the VIBI calculation from a 100 to a 90 point scale. In addition to documenting vegetation community composition and structure, PCAP monitoring assessments will also provide estimates of invasive plant species distributions, the extent and species preference of deer browse, and potential threats to forest infrastructure by forest pests and pathogens (i.e. emerald ash borer, gypsy moth, beech bark disease) by documenting distribution of susceptible species.

Preliminary results

VIBI and FQAI scores indicate that all major reservations have high quality communities needing protection and further assessment to determine the impact of future compromising disturbance (i.e. invasive species encroachment, deer herbivory, forest pests and pathogens). Conversely, the scores also indicate that all major reservations have highly degraded communities requiring major efforts to delineate and treat populations of invasive species present and identify and implement future restoration activities.

Across the 16 reservations sampled in 4 years, twelve major plant community types were identified that included the following upland communities: 1) beech maple forests, 2) mixed forest, 3) floodplain forests, 4) oak forests and woodlands, 5) hemlock-hardwood forests, 6) atypical successional/disturbed woody communities, 7) old farm fields; and wetland communities, 8) wet flatwoods, 9) wet meadow, 10) freshwater marsh 11) forest seeps, and 12) stream gravel-bar .

The upland communities (1, 2, 3, 4, and 5 listed above) represent a broad range of community types with highly variable plant composition. The average VIBI score in each community was 53.5, 50.4, 48.2, 51.5, and 47.8, respectively. However within each community types, VIBI scores varied considerably. For example, mixed forest had VIBI scores as low as 16 to as high as 77.

The Atypical and Old-Farm community types (6 and 7 listed above) are disturbed communities dominated by non-native or ruderal species with broad ecological ranges. As such, both communities have low average VIBI scores (32.0 and 15.5, respectively).

The wet flatwoods community (8 listed above) had an average VIBI score of 40.4. The wet meadow and stream gravel bar communities (9 and 12 listed above) had 9 and 5 sample plots, respectively while the freshwater marsh only had 4 plots with an average VIBI of 24.8. There 3 sample plots of forest seeps (11 listed above) from 2010 to 2013 . Based on these limited sample sizes, generalizations about community condition cannot be made.

Plant Community Assessment Program (PCAP)

Background:

The Plant Community Assessment Program (PCAP) is a long-term vegetation monitoring project that will report on the composition and existing condition of plant communities in Cleveland Metroparks and how these communities change over time. It includes both quantitative and qualitative assessments of plant communities occurring within the >22,000 acres of land holdings. Sampling will occur in randomly placed plots located in each Cleveland Metroparks reservation. Random plot locations were generated using the Generalized Random Tessellation Stratified (GRTS) survey design developed by the U.S. EPA Environmental Monitoring and Assessment Program (EMAP) (Diaz-Ramos et al. 1996, Herlihy et al. 2000, Olsen et al. 1999, Stevens 1997, Stevens and Olsen 1999, Stevens and Urquhart 1999, Stevens and Olsen 2004). A minimum of 400 permanent plots (~1 plot for every 55 acres) will be established throughout the Park District with the 7 major reservations (i.e., large) receiving 50 plots each and the 9 minor reservations receiving 50 combined (Table 1). Approximately 100 plots will be sampled each year for 4 years with year five provided for data analysis and comprehensive reporting. Six, 5-year cycles of sampling will occur from 2010 through 2029 (2,400 plot visits). In addition, sample points have been pre-selected for "shadow" reservations comprised of local catchments or areas where future land acquisition will occur. This will enable new plots to be established and included in the PCAP as the park expands in the future.

Table 1. Expected sampling effort and plot locations for one 5-year cycle of vegetation sampling for the Plant Community Assessment Program.

Stratum Reservations	Year_1	Year_2	Year_3	Year_4	Base Total	Over Sample	**Total**
Bedford	13	12	13	12	50	125	**175**
Brecksville	12	13	12	13	50	125	**175**
Hinckley	13	12	13	12	50	125	**175**
Mill Stream Run	12	13	12	13	50	125	**175**
North Chagrin	13	12	13	12	50	125	**175**
South Chagrin	12	13	12	13	50	125	**175**
Rocky River	13	12	13	12	50	125	**175**
Minor Reservations	12	13	12	13	50	125	**175**
Total	**100**	**100**	**100**	**100**	**400**	**1000**	**1400**

Over time, results will be used to assess the impact of management, wildlife, invasive species, and the surrounding urban matrix on the Park District's natural infrastructure. Information attained from this program provides context to guide and prioritize future conservation and restoration programs in subsequent years.

The goals of this program are to detect changes in vegetative composition and structure and ecosystem health to inform natural resource management decisions. Specific questions that will be addressed and the types of data collected to answer them are as follows:

1) What is the rate and direction of change for key plant species? Measurements of species frequency and size (basal area and coverage) will be used to test for changes among sampling periods and among reservations.
2) What is the rate and direction of change of plant community composition? Calculation of species richness and species diversity will allow tracking of community composition among reservations and over time.
3) What is the rate and direction of change of plant community structure? Measurements of size and spatial distribution of trees and species assemblages will provide estimates of regeneration and succession while providing insight on what factors are influencing these changes.

Rationale for Monitoring Vegetation Communities:

Vegetation is the trophic base for most other ecosystem components (Fortin et al. 2005). The plant communities of a region represent an integration of past and current climate, soils, and disturbances, including browse levels (Cote et al. 2004) and invasive species (Ojima et al. 1991), and can serve as a measure of overall ecosystem health (Randerson et al. 2002). Vegetation has been successfully used as indicator taxa for numerous wetland assessment methods in the United States (Mack and Kentula 2010). The National Park Service's vital signs program ranked it third of 46 indicators for inclusion in long-term monitoring programs behind inland lake and larger river water quality (Sanders et al. 2008). Vegetation also has other practical advantages for use in long-term monitoring and indicator development including a well-studied taxonomy with numerous regional and state-specific treatments, the large number of vascular plants in the flora of a region, and cost effective, well-established sampling methods.

Program Summary

The fourth sampling year (2013) for the Plant Community Assessment Program resulted in successful accomplishment of set objectives.

1.) Completed fourth sample period of base-line vegetation assessment (100 permanent monitoring plots, 405 total to date)
Continued:
    - Enhanced data collection for ash species as part of a cooperative emerald ash borer project with the U.S. Forest Service.
    - Invasive species survey surrounding the PCAP plots (1,500 acres searched with population estimates per species)
    - Buffer plot assessment to identify habitat stressor type and distance according to the USEPA National Wetland Condition Assessment

2.) Completed second assessment Royalview bike trail impact assessment (50 sites, 100 monitoring plots)
3.) Completed Acacia Reservation baseline vegetation assessment (40 monitoring plots)

PCAP staff included 11 seasonal crew members, the Vegetation Research Coordinator, and the Plant and Restoration Ecologist. Typically the seasonal personnel were divided into 2 to 3 crews with 3 to 5 people per crew including 1 crew leader and 1 botany assistant responsible for herbaceous data collection and taxonomic expertise; and 2 to 3 field members responsible for collecting woody stem data, tree measurements, and physical site characteristics. Data collection was initiated in June and ran consecutively for 13 weeks (6/12/2013-9/04/2013). On average, 8 plots were sampled per week (range 2-14).

Crew members were rotated on a weekly basis as a quality control measure to ensure data collection calibration. In addition to the dedicated crews, the Wetland Ecologist assisted periodically in data collection and quality control. Volunteers, interns, and other Natural Resource seasonal staff occasionally accompanied crews for cross-training experience.

Beyond the program's in-house management utilization, five different research collaborations have been established using the PCAP experimental design and data collection including: 1) an invasive worm survey with Cleveland State University, 2) an insect survey of beech maple communities with the Ohio State University OARDC, 3) spatial genetic variability of beech trees with Hiram College, 4) invasibiliy of forested communities with Case Western Reserve University, and 5) evaluation of background metals concentration in Cleveland area urban soils with Ohio EPA. PCAP crews also continued field data collection to develop a terrestrial

vegetation index of biotic integrity (VIBI), as well as develop written protocols for PCAP data entry and field procedures.

Experimental Design

In 2013, 100 permanent plots were established to monitor plant community structure and composition throughout Cleveland Metroparks. The community sampling plot design is modeled after the North Carolina Vegetation Survey as described in Peet et al. (1998) and Lee et al. (2008).

The plot layout is typically a 2 x 5 array of 10 m x 10 m modules resulting in a 20 m wide by 50 m long assessment area (1000 m^2=0.1 ha) (Figure 1). Four of the 10 m x 10 m modules are intensively sampled with a series of nested quadrats. In each of these "intensive" modules, all plant species are given a cover class value for the 100 m^2 area, and woody stem counts and measurements are conducted. In the remaining modules, only the woody stem data is collected, along with presence data for species not encountered in the intensive modules. According to protocol, all field data was collected between June 12 and September to maintain comparable seasonal community composition among plots and years.

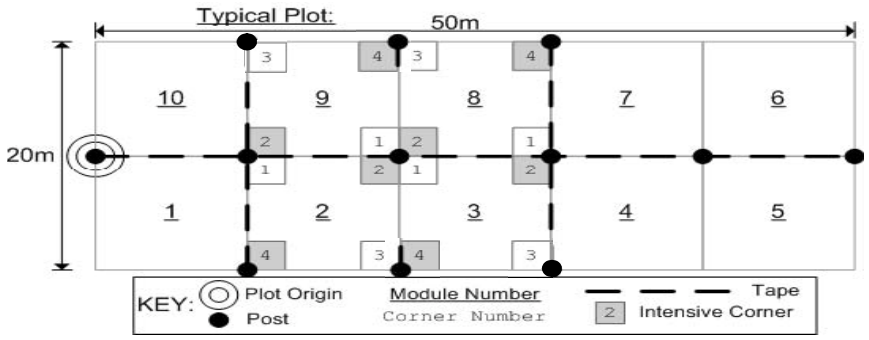


Figure 1. Representative 10-module plot layout indicating location of intensive sampling modules with shaded and open corners indicated

Because of the random plot distribution, PCAP was conducted in 13 of the 16 reservations. Washington, Garfield Park, and West Creek reservations were not included in the 2013 assessment, but were sampled in 2010, 2011, and 2012. The 6 smaller reservations (BW, BC, EC, Bk, Hu, OE) each had 1-3 GRTS monitoring plots established and measured. The 7 larger reservations (SC, NC, RR, MS, Hi, Br, Be) each had between 12-14 plots established and measured (Table 2).

Table 2. Reservation codes and number of plots visited and sampled in 2012.

Reservation	Code	No. Plots Visited 2013	No. Plots with complete data 2013
Bedford	Be	13	12
Big Creek	BC	2	1
Bradley Woods	BW	3	3
Brecksville	Br	13	12
Brookside	Bk	1	1
Euclid Creek	EC	1	1
Garfield Park	GP	0	0
Hinckley	Hi	16	14
Huntington	Hu	2	1
Mill Stream Run	MS	14	13
North Chagrin	NC	16*	12
Ohio & Erie Canal	OE	1	1
Rocky River	RR	17	13
South Chagrin	SC	18	14
Washington	Wa	0	0
West Creek	WC	2**	2
Total		**119**	**100**

Note: * One North Chagrin plot was surveyed in 2012 however it was determined as an additional plot for the 2012 sampling and therefore the plot replaced a limited data plot for 2013 sampling.

**Two West Creek plots were surveyed in 2010 however these plots sequentially belong in 2013 sampling therefore will be analyzed with the 2013 data.

There were 19 plots determined to be Limited Data Plots.

Plant Community Characterization

Prior to the start of sampling, rules were established to determine whether the full suite of data would be collected from each randomly located plot. Because some plot locations fell in lakes, rivers, mowed areas, and on areas that were deemed unsafe to sample (slope, proximity to cliff), only peripheral data was collected from these plots and are therefore recognized as Limited Data Plots (LDP). When these plots were encountered, a replacement plot was added to the survey to maintain the sampling quota for the reservation. Replacement plots were selected sequentially from a suite of oversample plots pre-generated during the initial experimental design phase. Consequently, a total of 119 plots were visited in 2013, and a complete vegetation assessment was completed for 100 plots in the 13 previously stated reservations (Table 2). The remaining 19 plots were Limited Data Plots. As a point of clarification, 10 plots at West Creek Reservation were surveyed as part of the National Science Foundation Urban Long Term Research Area Exploratory project (ULTRA-Ex) in 2010. One of these plots belonged sequentially to the 2011 sample and will be analyzed in the future as part of the 2011 dataset. In addition, two of these plots belonged sequentially to the 2013 sample thus will be analyzed in the future as part of the 2013 dataset.

Community Condition Assessment:

Habitat quality was determined using multiple community indices. The Vegetation Index of Biotic Integrity (VIBI) is a qualitative assessment of community condition (Mack 2007). We have modified the VIBI traditionally used for wetlands to assess drier upland communities. Currently under development, this modified VIBI for upland forests eliminates the metric for wetland specialist plants (% hydrophyte) which reduces the VIBI calculation from a 100 to a 90 point scale. The floristic quality assessment index (FQAI) was also used to identify community quality (Andreas et al. 2004). This index is based on each species coefficient of conservatism (C of C), which is a weighting factor that relates the degree of conservatism (or site fidelity) of a given species to all other species within the region. The C of C is scored on a 0-10 scale. Plants with a 0 score have wide ecological ranges are often opportunistic non-native species, or are native ruderal species. Plants with a score of 10 have a narrow habitat tolerance range or high degree of fidelity to a specific community type.

In addition to these community quality indices, composition was also assessed by identifying species assemblages based on their C of C value. Those species with C of C scores of 0-2 are considered tolerant species and are widespread taxa not typical or unique to a particular community. The % tolerance metric of a community is calculated by summing the relative cover of all tolerant species. Those species with C of C scores of 6-10 are considered sensitive species with narrow ecological ranges

and high fidelity to stable communities. The % sensitive metric of a community is calculated by summing the relative cover of all sensitive species.

Reservation Condition

Reservations sampled resulted in:

- 2013 had 13 total reservations
  - 6 minor and 7 major reservations
- 2012 had 13 total reservations
  - 6 minor and 7 major reservations
- 2011 had 15 total reservations
  - 8 minor and 7 major reservations
- 2010 had 14 total reservations
  - 7 minor and 7 major reservations

To establish a base community condition score, 14 additional plots were established as reference sites within specific communities. These Vegetative Index of Biotic Integrity Reference sites (VIBI Ref) are used for comparative conditions and represents 5 community types (Beech maple, Mixed forest, Oak woodland, Floodplain, and Hemlock hardwood). These plots are located throughout NE Ohio and include Cleveland Metroparks, Eagle Creek State Nature Preserve, Fowlers State Nature Preserve, Case Western Reserve University Squire Farm, and Cleveland Museum of Natural History Cathedral Woods. As such the 'VIBI Ref' sites score high in VIBI and FQAI indices with community composition primarily of sensitive plant species and only minor contribution by tolerant species. The tables below detail the community condition assessments (VIBI, FQAI, % sensitive, and % tolerant) for each reservation; Table 3 includes the 9 minor reservations whereas Table 4 lists the 7 major reservations.

Table 3. Community condition measurements for each minor reservation sampled combined sampling years. Modified VIBI (vegetation index of biotic integrity), FQAI (floristic quality assessment index), % Sensitive (species identified with coefficients of conservatism ≥6) and % Tolerant (species identified with coefficients of conservatism ≤2). Each reservation includes the combined results from 2010-2013.

Reservation	# of plots	VIBI (modified) Mean (min-max)	FQAI Mean (min-max)	% Sensitive	% Tolerant
Euclid Creek	5	44.2 (34-57)	16.9 (12-21)	24.5%	25.7%
Huntington	2	54 (53-55)	19.9 (18-22)	45.6%	29.2%
Bradley Woods	13	48.2 (13-71)	19.5 (14-28)	23.9%	31.8%
Brookside	5	35.6 (0-61)	16.7 (4-25)	41.6%	32.3%
Ohio & Erie Canal	6	24 (10-52)	11.7 (10-13)	5.67%	39.2%
Washington	1	20	8.3	0.1%	49.4%

Garfield Park	3	40.3 (30-58)	15.4 (12-21)	32.6%	31.8%
Big Creek	8	39.6 (10-54)	17.2 (7-21)	17.5%	43.6%
West Creek	10	36.9 (10-55)	17.9 (13-21)	34.5%	39.0%
VIBI Ref	**14**	**57.0 (32-74)**	**24.7 (16-34)**	**53.7%**	**8.4%**

Table 4. Community condition measurements for each major reservation sampled.
Modified VIBI (vegetation index of biotic integrity), FQAI (floristic quality assessment index), % Sensitive (species identified with coefficients of conservatism ≥6) and % Tolerant (species identified with coefficients of conservatism ≤2). Each reservation includes combined results from 2010-2013.

Reservation	# of plots	VIBI (modified) Mean (min-max)	FQAI Mean (min-max)	% Sensitive	% Tolerant
South Chagrin	50	45.1(9-77)	19.2 (7-31)	24.4%	37.8%
Bedford	49	37.7 (0-77)	17.6 (4-33)	24.1%	40.6%
Brecksville	52	52.1 (6-73)	21.4(7-34)	30.1%	22.4%
Rocky River	52	43.8 (0-66)	18.1 (2-29)	18.8%	19.7%
Hinckley	50	48.8 (0-77)	21.5(4-34)	18.3%	25.0%
Mill Stream Run	48	45.3 (17-71)	19.5(11-28)	25.9%	27.4%
North Chagrin	51	45.2 (13-77)	19.2 (8-31)	37.3%	25.3%
VIBI Ref	**14**	**57.0 (32-74)**	**24.7 (16-34)**	**53.7%**	**8.4%**

Minor Reservations:

The minor reservations had large variability in their VIBI score between the reservations. This variability is attributed in part by the small sample size in these reservations; with each reservation having between1-13 plots sampled (Table 3). Because of the limited sample size, the minor reservations were combined to include all four years of sampling (Figure 2). Overall, the average VIBI scores ranged from 20 (Washington) to 54 (Huntington).

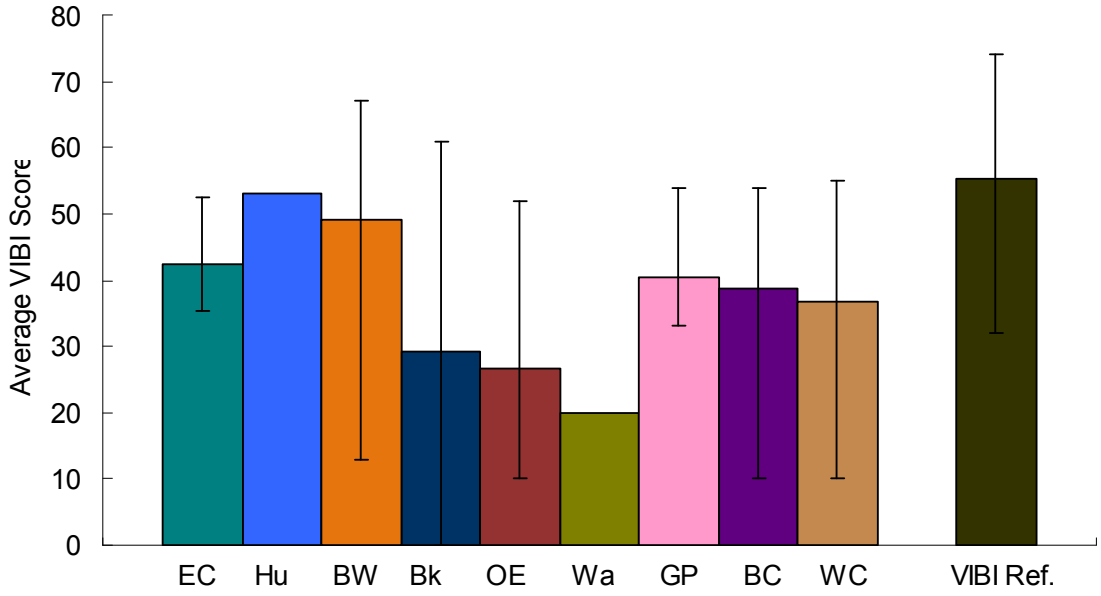


Figure 2. Average and range of VIBI scores for the minor reservations for the combined sample years of 2010-2013.

Major Reservations:

The major reservations showed little variability in average VIBI scores. The survey showed that the greater variability in community quality occurred within each reservation. The lowest scoring average VIBI 37.7 was in Bedford while the highest scoring average VIBI 52.1 was in Brecksville. The remaining major reservations averages fell with the 40s.

Each major reservation has high quality habitat (VIBI score >55 as indicated by the upper range of the "error bar") but there are also parts of each reservation that have very poor quality habitat (VIBI score 0-30 as indicated by the lower range of the "error bar").

Within the three years of sampling, Rocky River, Hinckley, and Bedford reservations had plots with a VIBI score of zero (0). These lower VIBI scores indicate areas where no tree canopy exists as in a meadow and/or highly disturbed or depauperate areas with plant communities composed mainly of tolerant species.

These preliminary findings indicate that all major reservations have some high quality communities needing protection and further assessment to determine the impact of future compromising disturbance (i.e. invasive species encroachment, deer herbivory, forest pests and pathogens). They also indicate that all major reservations have highly degraded communities that require major

efforts to delineate and treat the populations of invasive species present and identify future restoration capabilities.

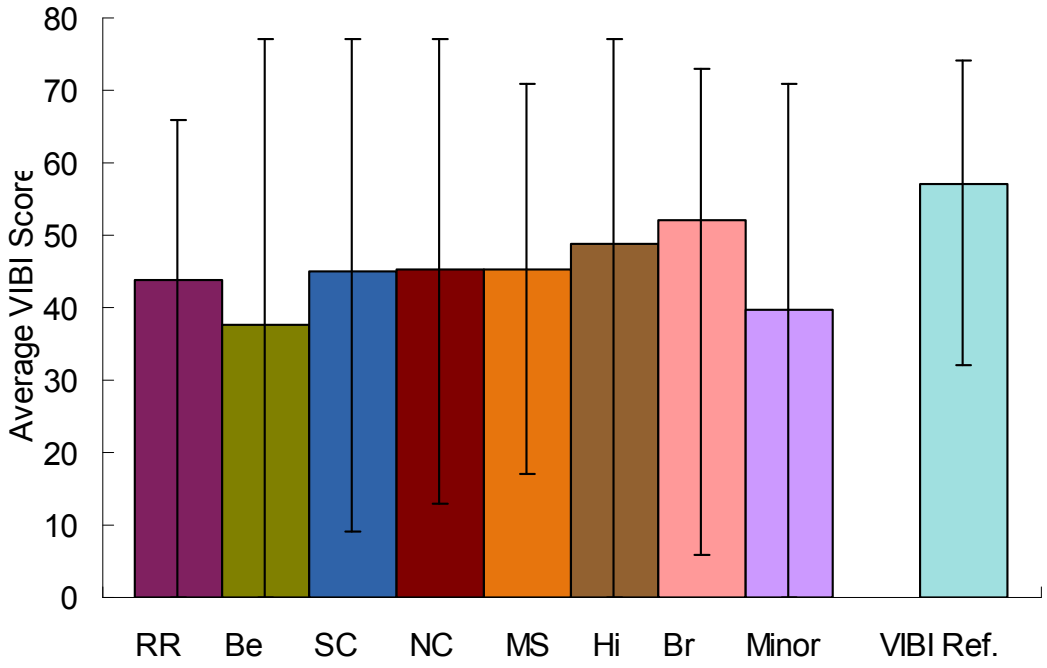


Figure 3. Average and range of VIBI scores for the major reservations samples in 2010-2013 and the combined minor reservations.

Table 5 . Proportion of VIBI scores greater than 60 and less than 30 in the major reservations and the combined minor reservations.

Reservation	Total # plots	% plots VIBI >60	% plots VIBI <30
Be	49	24.5%	36.7%
Br	52	42.3%	13.5%
Hi	50	34.0%	14.0%
MS	48	8.3%	10.4%
NC	51	23.5%	15.7%
RR	52	23.1%	17.3%
SC	50	24.0%	24.0%
Minor	53	11.3%	24.5%

The percentage of VIBI scores for each major reservation reveals every reservation except Mill Stream Run and the combined minor reservations had at least 20% of the points sampled score a 60 or higher.

Reservations with a large proportion of VIBI scores lower than 30 include Bedford and the minor reservations. Bedford reservation had over 35% of the plots sampled score less than 30. Mill Stream Run reservation had the lowest percentage of VIBI in both categories with less than 10% score higher than a 60 and around 10% for fewer than 30. This indicates most of the plots in Mill Stream Run scored in the middle range and management efforts should focus on elevating the quality of habitats in this reservation.

These preliminary findings indicate that all major and combined minor reservations have some high quality communities needing protection. They also indicate that all major and combined minor reservations have highly degraded communities however these proportions indicate a more highly focused restoration effort is needed in Bedford, Mill Stream Run, South Chagrin and the minor reservations.

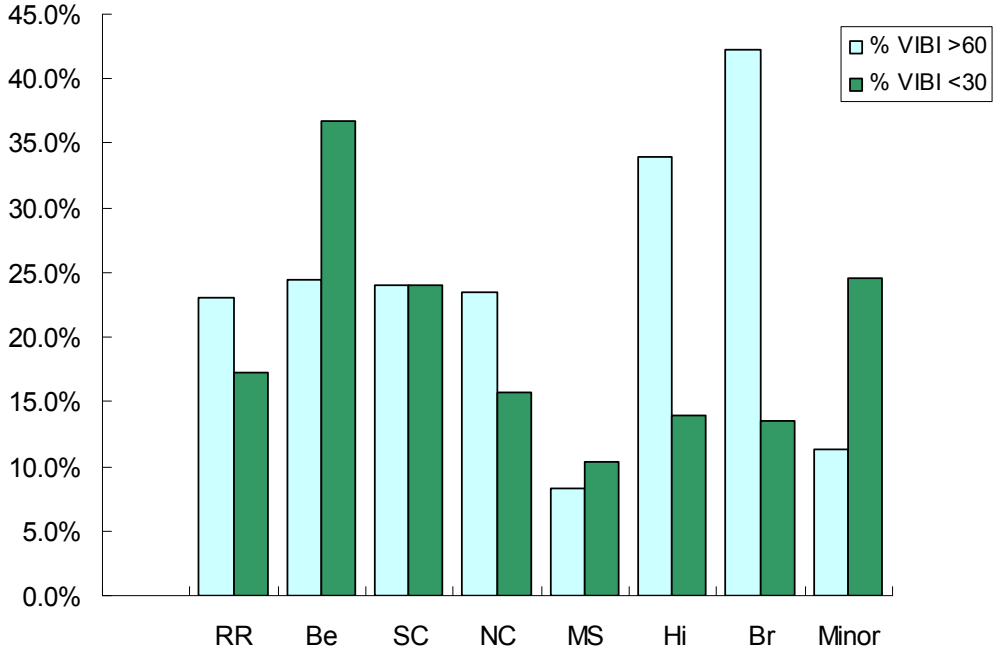


Figure 4. Percentage of VIBI scores greater than 60 and less than 30 for the major reservations an the combined minor reservations

Plant Community Characterization and Condition

Over the past 4 sampling years we have identified 12 major community types in Cleveland Metroparks based on a modified U.S. National Vegetation Classification System developed by Nature Serve (Appendix 1). The sampling scheme and basic community distribution for each year are as follows:

- 2013: 13 reservations
    - 117 total plots
        - 10 major plant communities
        - 20 minor plant communities
- 2012: 13 reservations
    - 117 total plots
        - 11 major plant communities
        - 23 minor plant communities
- 2011: 15 reservations
    - 119 total plots
        - 12 major plant communities
        - 28 minor communities
- 2010: 14 reservations
    - 123 total plots
        - 10 major plant communities
        - 24 minor community communities

The subsequent tables provide information about each major community type and describe community condition with the following qualitative measures: Modified VIBI (vegetation index of biotic integrity), FQAI (floristic quality assessment index), % Sensitive (species identified with coefficients of conservatism ≥6) and % Tolerant (species identified with coefficients of conservatism ≤2). Figure 5 illustrates the proportion of each major plant community sampled in 2010-2013

Beech Maple Forest:

The Beech Maple Forest is typically found on flat to rolling uplands to steep slopes over rich glacial till. This community is characterized by a dense tree canopy with a thick layer of hummus and leaf litter leading to a diverse and dense herbaceous layer. This major community type is further subdivided into 3 specific community designations (Beech Maple, Sugar Maple and Beech Red Oak).

	# of plots	VIBI score (min - max)	FQAI score (min - max)	% Sensitive	% Tolerant
2013	13 plots (11.1)	53.2 (35-74)	22.4 (17-28)	41.5%	10.4%
2012	10 plots (8.6%)	49.4 (33-63)	18.8 (16-26)	42.0%	8.6%
2011	20 plots (16.8%)	60.4 (36-77)	24.8 (15-34)	52.6%	3.5%
2010	33 plots (26.8%)	50.6 (17-73)	21.9 (12-33)	35.3%	14.0%
Average Total	**75 plots (15.8)**	**53.5 (17-77)**	**22.3 (12-34)**	**41.9%**	**9.9%**

Mixed Forest:

These communities often lack clear species dominance as they are likely in various stages of secondary succession. Dominant tree species may include red oak, basswood, tulip tree or ash. This community type may be found in areas that have been cut over and harvested.

	# of plots	VIBI score (min - max)	FQAI score (min - max)	% Sensitive	% Tolerant
2013	30 plots (25.6%)	51.1 (16-77)	21.0 (13-32)	29.6%	24.5%
2012	41 plots (35.0%)	51.4 (19-77)	20.3 (13-29)	37.8%	22.1%
2011	23 plots (19.3%)	20.5 (28-77)	20.5 (13-29)	34.3%	22.8%
2010	25 plots (20.3%)	48.4 (23-67)	22.1 (13-33)	25.7%	20.2%
Average Total	**119 plots (25.0%)**	**50.4 (16-77)**	**20.9 (13-33)**	**32.5%**	**22.5%**

Floodplain Forest:

These forests are often subjected to flooding and have multiple dominant or co-dominant tree species that determine the specific community structure. Two specific sub-communities were sampled in 2013: 1) Mesic floodplain (23 plots) and 2) Cottonwood floodplain (2 plots).

	# of plots	VIBI score (min - max)	FQAI score (min - max)	% Sensitive	% Tolerant
2013	25 plots (21.4%)	47.6 (10-71)	20.3 (11-29)	14.8%	21.3%
2012	14 plots (12.0%)	52.9 (24-74)	21.3 (12-30)	19.5%	16.0%
2011	19 plots (15.9%)	46.5 (13-70)	20.1 (13-34)	19.3%	28.2%
2010	18 plots (14.6%)	47.2 (12-67)	20.7 (10-30)	16.5%	19.9%
Average Total	**76 plots (16.0%)**	**48.2 (10-74)**	**20.6 (10-34)**	**17.2%**	**21.7%**

Atypical Successional:

These community types indicate previous disturbance events and represent early forest succession consisting of various shrub thickets. Four types of successional communities were identified 1) Planted communities (3 plots), 2) Red maple thicket and woodland, often sassafras is co-occurring (6 plots), 3) Upland shrub thicket/other (3 plots).

	# of plots	VIBI score (min - max)	FQAI score (min - max)	% Sensitive	% Tolerant
2013	12 plots (10.3%)	35.2 (12-57)	16.6 (13-20)	11.1%	45.5%
2012	12 plots (10.3%)	33.8 (16-60)	15.0 (11-21)	11.1%	52.0%
2011	16 plots (13.5%)	33.3 (10-58)	17.0 (9-26)	11.0%	54.8%
2010	9 plots (7.3%)	23.9 (7-42)	13.3 (8-19)	5.8%	67.3%
Average Total	**50 plots (10.5%)**	**32.0 (7-60)**	**15.7 (8-26)**	**10.0%**	**54.4%**

Oak Forest and Woodland:

These communities occur on dry-mesic soil conditions. Forest cover can range from a dense to moderately open canopy and soils are typically well-drained.

	# of plots	VIBI score (min - max)	FQAI score (min - max)	% Sensitive	% Tolerant
2013	2 plots (1.7%)	55 (50-60)	28.1 (25-31)	48.1%	3.4%
2012	1 plot (0.85%)	39.0	15.4	46.6%	0.51%
2011	3 plots (2.5%)	50.7 (25-64)	24.4 (17-28)	46.6%	20.6%
2010	7 plots (5.69%)	52.6 (44-64)	22.6 (19-31)	46.4%	25.4%
Average Total	**13 plots (2.73%)**	**51.4 (25-64)**	**23.3 (15-31)**	**46.7%**	**19.0%**

Farming and Forest Harvesting:

This community type includes old farm fields that have reverted to open meadows. Plots may be identified as old or young field meadows that may receive periodic management (brush-hogging or fire) to maintain open community structure by removing woody species encroachment. This community is dominated by opportunistic species with broad ecological tolerances. These meadow plots typically score low using the Forested VIBI because they lack woody stems.

	# of plots	VIBI score (min - max)	FQAI score (min - max)	% Sensitive	% Tolerant
2013	5 plots (4.3%)	20.6 (6-37)	11.2 (7-16)	4.5%	67.7%
2012	9 plots (7.7%)	11.3 (0-26)	7.2 (4-12)	0.89%	67.9%
2011	7 plots (5.9%)	12.4 (0-36)	8.4 (5-12)	3.3%	67.6%
2010	6 plots (4.9%)	21.2 (0-44)	12.5 (4-19)	11.6%	53.5%
Average Total	**27 plots (5.67%)**	**15.5 (0-44)**	**9.45 (4-19)**	**4.6%**	**64.6%**

Wet Flatwoods:

Wet Flatwoods occur on somewhat poorly drained uplands or in depressions associated with glacial features. Saturation can vary, with ponding common during wetter seasons and drought possible during the late summer months. Microtopography and fluctuating moisture levels can lead to complex forest upland and wetland species occurring within this community type. This major community descriptor includes several sub-community designations that are identified based on the dominate tree species. These include one of the following; Maple ash swamp, Green ash swamp, Mixed swamp forest.

	# of plots	VIBI score (min - max)	FQAI score (min - max)	% Sensitive	% Tolerant
2013	5 plots (4.27%)	40.4 (23-59)	17.1 (11-23)	8.9%	41.5%
2012	3 plots (2.6%)	33.7 (17-47)	15.0 (11-20)	5.46%	59.7%
2011	4 plots (3.4%)	40.5 (27-67)	20.5 (16-28)	10.9%	38.5%
2010	6 plots (4.9%)	42.2 (22-61)	18.6 (16-24)	7.9%	57.4%
Average Total	**18 plots (3.78%)**	**40.4 (17-67)**	**18.0 (11-28)**	**8.4%**	**49.2%**

Hemlock- Hardwood Forest:

This community occurs on somewhat protected low and midslopes and valley bottoms. The canopy is usually characterized by Hemlock and may contain other northern hardwoods including sugar maple, yellow birch, beech maple, and occasionally red oak.

	# of plots	VIBI score (min - max)	FQAI score (min - max)	% Sensitive	% Tolerant
2013	none				
2012	2 plots (1.7.1%)	52.3 (39-66)	20.8 (16-26)	76.7%	0.35%
2011	3 plots (2.5%)	45.3 (33-55)	20.6 (19-23)	62.8%	8.2%
2010	1 plot (0.81%)	46.0	17.1	68.3%	2.6%
Average Total	**6 plots (1.26%)**	**47.8 (33-66)**	**20.1 (16-26)**	**68.3%**	**4.6%**

Freshwater Marsh:

Freshwater marshes may be open ponds with floating or rooted aquatics, or deep marsh with bulrush or cattails, and range from fairly small to several acres. It contains hydric soils flooded by water ranging from several centimeters to over a 1 meter for most of the growing season.

	# of plots	VIBI score (min - max)	FQAI score (min - max)	% Sensitive	% Tolerant
2013	none				
2012	1 plot (0.85%)	36	10.1	42.9%	1.08%
2011	2 plots (1.7%)	26.5 (0-53)	9.9 (2-18)	14.0%	72.7%
2010	1 plot (0.81%)	10	6.7	0	71.2%
Average Total	**4 plots (0.84%)**	**24.8 (0-53)**	**9.2 (2-18)**	**17.7%**	**54.5%**

Wet Meadow:

Wet Meadow community types are typically found on glacial potholes, river valleys, ponds, and on lake plains. This community type has wet mineral soils or shallow peat with the water table just below the surface for most of the growing season. Trees are generally absent or if present, scattered.

	# of plots	VIBI score (min - max)	FQAI score (min - max)	% Sensitive	% Tolerant
2013	3 plots (3.4%)	42.3 (33-54)	10.3 (6-17)	0.95%	66.7%
2012	4 plots (3.42%)	50.5 (23-67)	15.1 (7-21)	7.77%	70.4%
2011	1 plot (0.84%)	65.0	20.7	12.5%	25.0%
2010	1 plot (0.81%)	27	6.5	0.0%	33.2%
Average Total	**9 plots (1.89%)**	**46.8 (23-67)**	**13.2 (6-21)**	**5.2%**	**60.0%**

Forest Seeps:

This is an herbaceous-dominated community therefore tree and shrub cover may vary, particularly from overhanging upland trees. Stands can occur along the lower slopes of glacial moraines, ravines and in deep glacial meltwater-cut river valleys at the bases of slopes separating stream terraces. Soils are seasonally to more-or-less permanently saturated.

	# of plots	VIBI score (min - max)	FQAI score (min - max)	% Sensitive	% Tolerant
2013	2 plots (1.7%)	34 (33-35)	18.5 (18-19)	5.5%	53.6%
2012	none				
2011	1 plot (0.84%)	68.0	19.4	49.4%	9.9%
2010	none				
Average Total	**3 plots (0.63%)**	**24.8 (0-53)**	**9.17 (2-18))**	**17.7%**	**54.5%**

Stream Gravel-Bar:

The Stream Gravel-Bar is raised gravel sediment deposited by the stream flow. Fluctuating water levels in the stream throughout the year create dynamic change in the size, shape, and vegetation on the gravel bar.

	# of plots	VIBI score (min - max)	FQAI score (min - max)	% Sensitive	% Tolerant
2013	1 plot (2.6%)	6	9.9	6.0%	86.5%
2012	3 plots (2.56%)	22.7 (0-34)	9.5 (4-13)	10.0%	40.7%
2011	1 plot (0.84%)	10.0	9.4	30.3%	36.7%
2010	none				
Average Total	**5 plots (1.05%)**	**16.8 (0-34)**	**9.53 (4-13)**	**13.3%**	**49.0%**

Limited Data Plots: (Figure 6)

Limited Data Plots (LDP) had only peripheral data collected because they were deemed unsafe to sample due to slope, the location fell in a river, occurred on paved parking lots, or on disturbed soil communities such as mowed areas (golf courses, road rights-of-way, playgrounds, baseball fields).

	# of plots	Reservoirs	Rivers	Mowed	Paved	Unsafe	Active Farming	Buildings and other structures
2013	19 plots (14.5%)		2 plots	8 plots	4 plots	3 plots		2 plots
2012	17 plots (14.5%)		2 plots	5 plots	3 plots	6 plots	1 plot	
2011	19 plots (15.9%)	3 plots	5 plots	8 plots	3 plots			
2010	16 plots (12.9%)		1 plot	9 plots	2 plots	4 plots		
Total	**71 plots (14.9%)**	**3 plots**	**10 plots**	**30 plots**	**12 plots**	**13 plots**	**1 plot**	**2 plots**

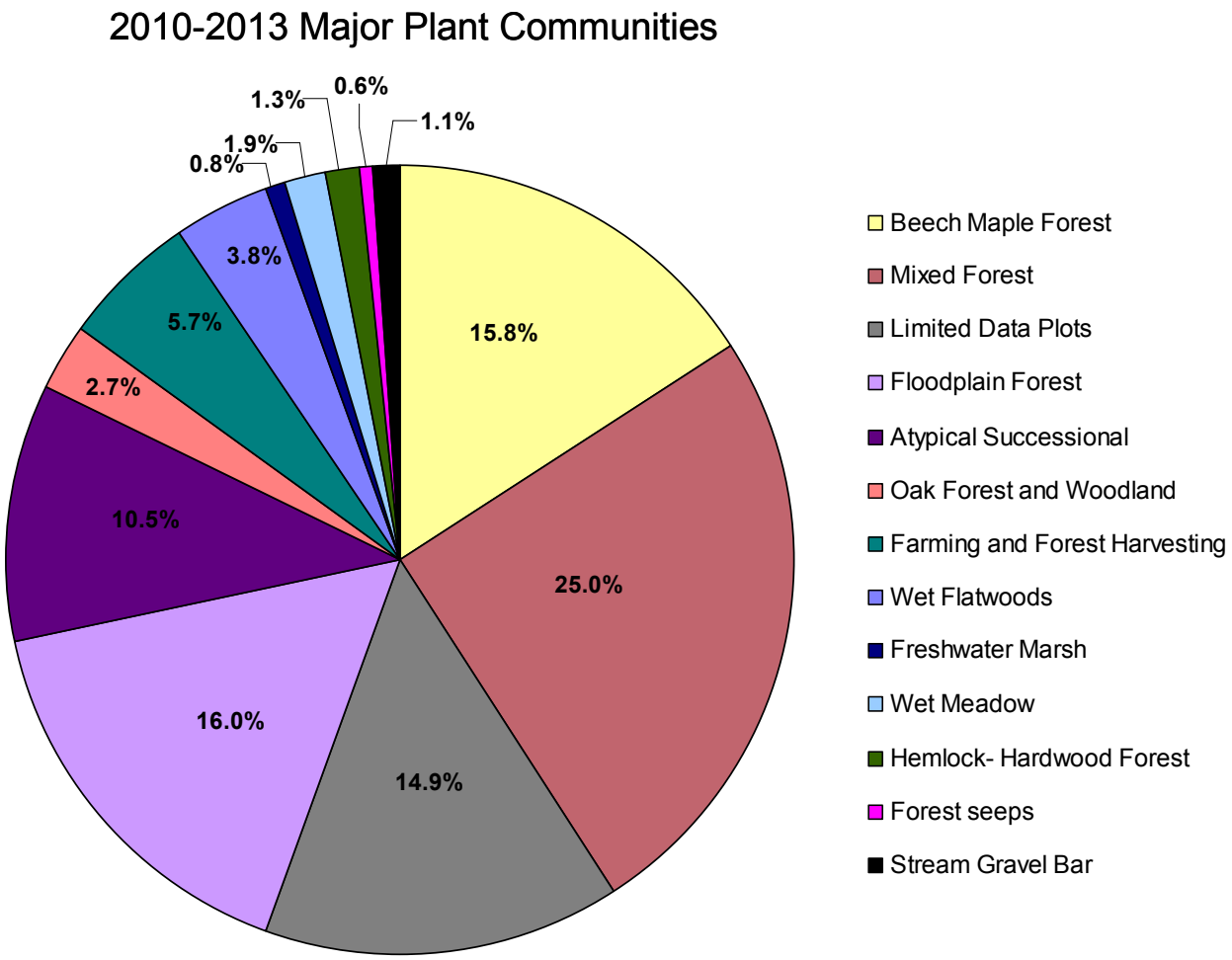


Figure 5. Distribution of random plot locations by major plant community types sampled (modified Nature Serve community classification).

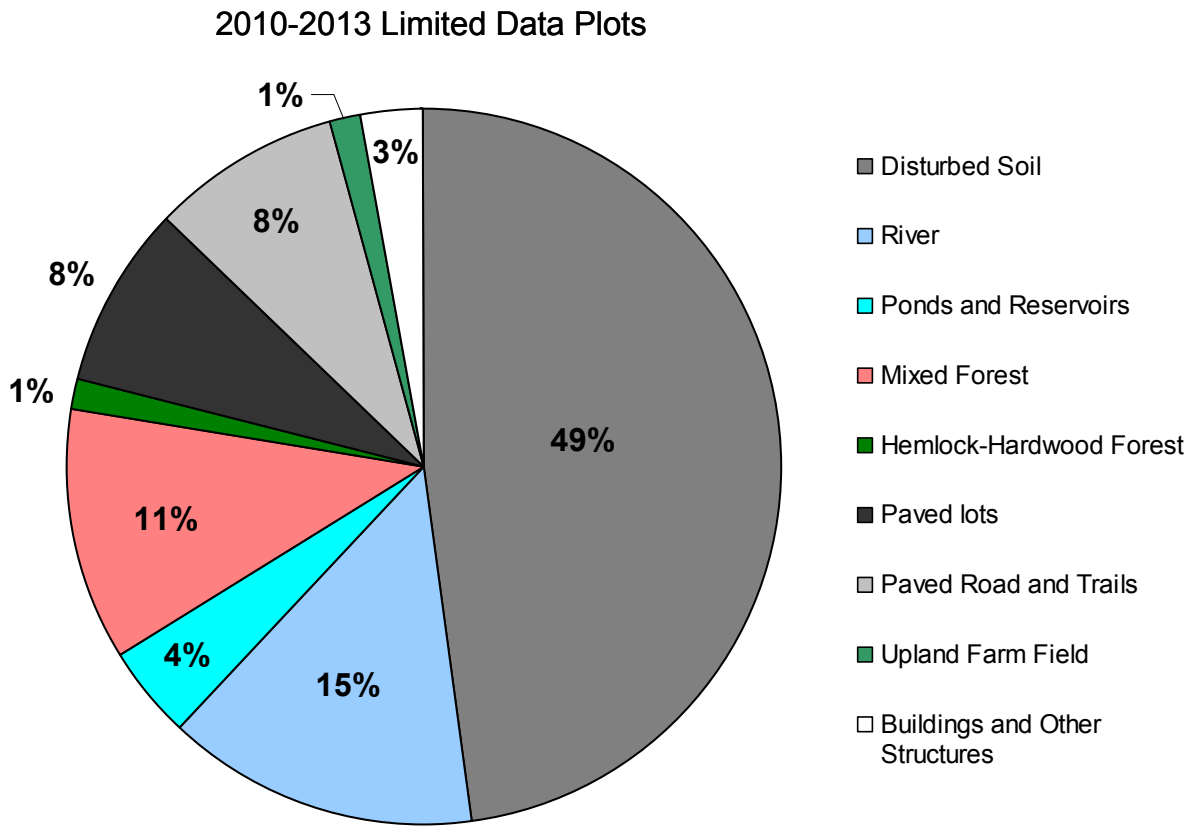


Figure 6. Categories for classifying sampling plots as LDP.

Limited Data Plots (LDP) had only peripheral data collected because they were deemed unsafe to sample due to slope (mixed forest/hemlock-hardwood), plot location fell in a river, occurred on paved lots/roadways/trails, or on disturbed soil communities (mowing).

Emerald Ash Borer

In cooperation with the U.S. Forest Service, we are collecting ash condition data including diameter at breast height (DBH), and crown condition, as well as EAB indicator data including presence of epicormic branching and woodpecker damage, and number of EAB exit holes on all ash trees encountered during sampling.

In 2013, Ash trees were found in 9 of the 13 reservations sampled. The five reservations (,Bk, BC, Hu, and OE) that did not have ash trees recorded had only 1 plots surveyed in 2013. This limited sample size does not accurately reflect the presence or absence of ash in those reservations. Out of the 405 total plots surveyed, ash occurred in over one-third of them (36.8%). Within each reservation the occurrence of ash within plots varied from 10.0% to 62.5%

(Table 5). Four reservations (BC, MS, Hi, Hu) had significant ash distribution with trees present in half or more of their plots however Hu had only two plot sampled subsequently the limited sample size may not accurately reflect the presence of ash in these reservations.

Table 6. The table displays the total number of plots sampled within each reservation, the number of plots with ash trees, and the percentage of plots with ash by reservation. Each reservation includes results from 2010-2013.

Reservation	Total # of plots sampled	# plots w/ash	%plots w/ash
Big Creek	8	5	62.5%
Hinckley	50	29	58.0%
Mill Stream Run	48	27	56.3%
Rocky River	52	23	44.2%
Bedford	49	13	26.5%
Bradley Woods	13	6	46.2%
North Chagrin	51	15	29.4%
South Chagrin	50	14	28.0%
Brecksville	52	1	10.0%
West Creek	10	13	25.0%
Euclid Creek	5	1	20.0%
Brookside	5	0	0.0%
Washington	1	0	0.0%
Ohio & Erie Canal	6	0	0.0%
Huntington	2	1	50.0%
Garfield Park	3	1	33.3%
TOTALS	**405**	**149**	**36.8%**

According to our direct measurements, ash accounted for 182 ash trees (*Fraxinus* sp.) (Table 6). One hundred and fifty-seven (157) ash trees were not identified to species, *Fraxinus spp.* The rest of the trees surveyed were green ash *Fraxinus pennsylvanica* (24), and one tree was identified as white ash *Fraxinus americana* (1). In 2013, the size of ash ranged from 10.2 to 86.8 cm while the average size of ash measured 12.0 for white and 24.2 for green.

Table 7. 2013 Average size and number of ash trees encountered by species across all reservations.

By Species	# of trees	Avg. DBH (cm)
Fraxinus americana (White)	1	12.0
Fraxinus pennsylvanica (Green)	24	24.2
Fraxinus spp.	157	27.1
Total	**182**	**15.8**

All individual ash trees within a plot were then measured and assessed for tree condition (Table 7). Diameter at breast height (DBH) is a measurement of trees size and a proxy for dominance. Canopy condition is determined by assigning an average crown rating developed to identify dieback on a 1-5 scale (Smith 2006).

Crown Ratings

1. Healthy, full canopy tree: Complete canopy
2. Thinning canopy: All branches have leaves but the canopy appears sparser than it should.
3. Dieback: Canopy is thinning with some dead branches at the top.
4. >50% Dieback: Canopy has less than half the leaves of a healthy tree and/or ½ of the top branches are dead
5. Dead Tree: No leaves remain. Applies even if there are epicormic sprouts along boll of tree.
6.

In addition, the program added a dead condition or breakup score to the ash that were rated an ash condition of 5 or a dead tree rating for 2011 to help estimate the rate of dead decline (USFS ranking system in development, K. Knight).

Dead condition

- **A.** All main branches contain fine twigs
- **B.** Over 50% of main branches have fine twigs
- **C.** Less than 50% of the main branches have fine twigs
- **D.** Stem still standing and tertiary main branches present
- **E.** Central stem still standing

External stress symptoms were also assessed for individual trees as a proxy for EAB activity. These stress symptoms include counting the number of adult exit holes observed at eye level ($1.25m \leq x \leq 1.5m$) around the bole of the tree, the presence (1 = present, 0 = not present) of epicormic branching, and the presence (1 = present, 0 = not present) of woodpecker activity. Epicormic branches are small lateral branches that are produced along the lower portion of tree trunks which sometimes branch as a result of stress. Woodpecker activity is observed as damage to the tree trunk and appears as flecking or small areas with missing bark.

Table 8. Ash tree condition, based on EAB indicator characteristics for each reservation in 2013. Average size and canopy condition included as well as the number of trees showing external symptoms of EAB infestation (#EAB exit holes, Epicormic branching, Woodpecker damage and #Dead condition).

Res. Code	# Ash trees	Avg. DBH (cm)	Avg. Crown Rate	# EAB exit holes	Epicormic branching	Woodpecker flecking/ damage	# Dead condition
South Chagrin	15	28.3	2.0	4	4	7	2
Rocky River	39	40.4	2.8	112	6	27	10
North Chagrin	10	21.9	2.0	6	4	2	1
Mill Stream Run	55	23.0	3.2	147	24	35	15
Hinckley	49	20.1	3.5	50	12	15	21
Bradley Woods	2	23.8	1.0	0	0	0	2
Brecksville	7	21.6	2.4	10	1	2	1
Bedford	4	28.2	1.3	1	1	1	1
Euclid Creek	1	61.5	3.0	0	0	1	0

Ash species are affected by numerous insect and disease causing organisms as well as stress factors such as drought and physical damage; therefore, crown condition ratings may be influenced by factors other than EAB. EAB exit holes, while proof of EAB presence, are usually symptoms of later stages of infestation, especially when present at eye level. Absence of EAB exit holes does not necessarily indicate that EAB is not present at a particular location. Presence of epicormic branching and especially woodpecker activity (flecking) are considered better earlier detection methods for EAB presence.

In general, crown condition of ash trees sampled showed dieback and canopy thinning with lowest average ratings in Hinckley and Mill Stream Run reservations. Mill Stream Run reservation recorded numerous ash trees with epicormic branching. Woodpecker flecking and damage are prevalent throughout the reservations with Mill Stream Run reservation recording the most activity. Dead condition only reports on standing dead ash trees and does not account for fallen ash trees. Identified standing dead ash trees are not necessarily attributed to EAB infestations. Overall, dead conditions ranked a category C or below where less than 50% of the canopy have fine twigs. Fine twigs do not remain long on dead ash trees.

Deer Browse

Since the early 1980s, the Cleveland Metroparks Natural Resources department has been monitoring the deer population. Field surveys showed a rapid decline in interior forest plant communities resulting from increased deer densities by the late 1980's. Culling to reduce the deer population began in 1998. In 2003, a forest vegetation survey started collecting data to determine areas with heavy browse and to track changes in vegetation with deer density reduction through deer management.

The PCAP assessment continues to document deer browse pressure based on the Charles Thomas (Cleveland Metroparks botanist) ranking system. Browse ratings are determine by evidence of a browse line, plant reproduction on preferred species, and the percentage of plants browsed within the plot. Severity of deer browse is recorded within the intensive module and rated as: low (<10% by numbers of stems browsed), medium low (~10% stems browsed but no impact on reproduction), medium (10-25% stems browsed with browse line not evident), medium high (~25% stems browsed and very little regeneration), high (>25% stems browsed and a browse line), and very high (almost all plants browsed or missing, 5-6' browse line).

Table 9. Number of plots in each category for deer browse intensity by reservation. The severity of browse is recorded as: low (<10%), medium low (~10%), medium (10-25%), medium high (~25%), high (>25%), and very high (little or no green understory). Each reservation includes the combined results from 2010-2013.

Reservation	Total # of plots	Low	Medium Low	Medium	Medium High	High	Very High	No Browse recorded
Minor								
BC	8			2	1	5		
Bk	5	1	2	1				1
Hu	2	1			1			
BW	13		1	2	4	4	2	
EC	5	1		1		3		
GP	3	1			1	1		
OE	6	2		1	1	2		
Wa	1							1
WC	10			1		3	6	
Major								
Be	49	2	6	14	5	10	8	4
Br	52	4	12	13	10	13		
Hi	50	9	5	19	10	7		
MS	48		6	14	14	13	1	
NC	51	6	8	13	10	9	1	3
SC	50	5	6	10	14	13	1	1
RR	52	5	8	13	5	17	3	1
TOTAL	**405**	**37**	**54**	**104**	**76**	**100**	**22**	**11**
Percent of Plots		**Low browse 22.5%**		**Medium 44.4%**		**High browse 30.1%**		

All the reservations assessed found some evidence of deer browse except Washington which did not documented browse. Washington reservation had only one plot assessed therefore no conclusive information is determined for browse severity in this reservation. In 2010, West Creek reservation had all 10 plots assessed with six plots (60%) rating very high in severity.

Of the 405 plots sampled, a little over 40% are documented as medium browse where 10% to 25 % of the stems are browsed in the plot and the regeneration is limited. High browse recorded at 30.1% or a little over a third of the plots sampled saw more than 25% of the stems browsed, an evident browse line, and severely limited to potentially no green growth beneath 6 feet. In combining medium and high browse percentages, approximately 75% of PCAP plots have deer browse limitations on plant reproduction.

PCAP is currently in the baseline sampling years and is an assessment of the current community conditions where evidence of deer browse is inhibiting regeneration. As the long term monitoring progresses, PCAP assessments will provide more information for deer management decisions. Ultimately, the management goal would be to shift the majority of occurring browsed stems into the low browse category and regain established regeneration of plant communities.

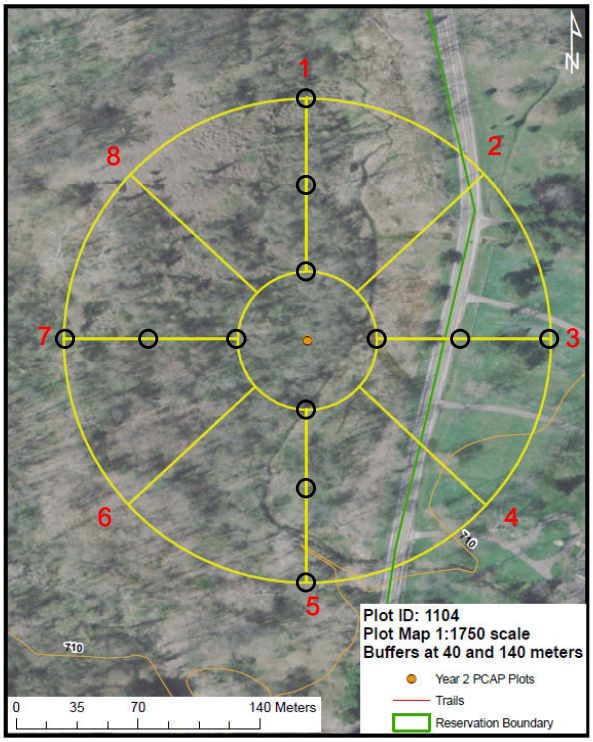
Buffer Plots

Initiated in 2011, this effort was added to the PCAP protocol and was established based on the guidelines from the National Wetland Condition Assessment (US EPA 2011). The protocol identifies vegetation cover by strata and determines surrounding influences or stressors attributed to residential/urban, hydrology, agricultural and rural, industrial development, and habitat/vegetation stressors. Data recorded for the buffer plots includes the assessment of each strata of the plot in five different size classes: 0) absent, 1) less than 10%, 2) 10-40%, 3) 40-75%, and 4) greater than 75%. Additionally, the protocol identifies the presence of 24 targeted invasive species.

In the field, three (3) circular 10 m diameter buffer plots are surveyed on each of the cardinal compass lines. The middle of the buffer plots fall 45 m, 90 m and 135 m away from the center plot. The center plot is typically located on centerline of the PCAP plot at 20 m, not at the GRTS point. Buffer plots establish the type and the distance to nearest disturbance or stressor.

In addition, buffer line widths are measured from the provided aerial maps on the 8 compass lines (4 cardinal and 4 ordinal) to determine the distance to the nearest stressor and to calculate the average buffer distance for each plot. Each line is measured by hand to the nearest edge (or disturbance). Edges or disturbances include human activities such as mowing, parking lots, roads, trails, and park property boundaries. Each buffer map contains 8 compass lines (4 cardinal and 4 ordinal) – SEE PICTURE 1. Each line segment begins at 40 m from GRTS point (Assessment Area (AA) center according to US EPA 2011). In 2011, each line represented 100 meters and measured 5.6 centimeters. If no disturbances are encountered along the line then the line measured 5.6cm. In 2012, the line measurement changed because the maps were created from the GIS server. The line length currently measures 5.3 cm to represent 100 meters.

The results for the buffer plots are still being compiled and will be reported soon.



Picture 1. Buffer map in field data folder

This is a buffer map showing the 3 circular plots sampled per cardinal direction (1, 3, 5, and 7) lines. Each directional line segment starts at 40 m from plot. Lines 1, 5, 6, 7, 8 measure 5.6 cm. A paved road disturbs line 2 at 3.7 cm, line 3 at 1.6 cm, and line 4 at 2.3 cm. Example distance measurements for each line segment

Invasive Plants

In addition to the buffer plot surveys, an invasive plant survey was added in 2011. In returning to buffer plot center, after buffer plots are surveyed along the cardinal line, crews wandered through the ordinal quadrants to record the occurrence of invasive plants. Forty-four (44) invasive plants were classified into a four tier system depending on the available ecological information and management action designated by the Invasive Plant Coordinator (Table 9).

In conjunction with the invasive plant survey, a pocket guide to invasive plants was prepared and published by the PCAP staff, titled: Cleveland Metroparks Guide to Invasive Plant Species (CM Report 2011/NR-07). The purpose of the guide was to educate the PCAP crew members unfamiliar with the targeted invasive plants as well as providing an educational tool for other departments within the Cleveland Metroparks.

Tier 1 – Early Detection/Rapid Response:

Tier 1 contains the invasive plants that require early detection and rapid response. These species are known to be highly invasive in natural areas but are not yet widespread in the Cleveland Metroparks. With limited distribution, immediate action would minimize management cost and long-term ecological impact of these aggressive species. The PCAP crew collects a GPS point and records directions to the location. The Invasive Plant Coordinator should be notified immediately with the collected information. Definite and immediate actions are required by the Invasive Plant Strike Team, if a Tier 1 invasive plant is discovered.

Tier 2 – Assess as Needed:

Tier 2 designated plants are assessed as needed. The size and extent of these species populations are currently being inventoried with limited geographical information available. Population size may be highly variable. This survey will assist with identifying future control targets as populations are delineated. These species are recorded within the ordinal quadrant found and given an approximate number of plants stems size class (Table 9).

Tier 3 – Presence is of Interest:

The third tier (Tier 3) contains plant species of interest. The species that occur in this tier are likely ornamental escapes. It is not known whether they are established and/or spreading within Cleveland Metroparks. The ecological impact is poorly known for these species. Initial population numbers are likely small. These species are recorded within the ordinal quadrant found and given an approximate number of plants stems size class (Table 10).

Tier 4 – Widespread and Abundant:

The last tier (Tier 4) includes invasive plants that are widespread and abundant. These are know problem species throughout the Cleveland Metroparks and are currently under active management. Management plans are set using population extent and site-specific information. In 2011, these species were recorded as present or absent. Beginning in 2012, this tier was recorded as an approximate number of plants stem size class (Table 10).

In addition to recording the size class for the number plant stems, the groundcover plants (i.e. Vinca minor) include a description of plant colonies and the patch size (S, M, L)

Table 10. PCAP invasive plant survey based on the total plot occurrence for each targeted invasive species from 2011-2013(298 plots), the 2012-2013 average size class and the average estimated population size (plant count) for 2012-2013.

Tier Level	Species	# of plots	%plots with species	2012-2013 Average # of plants range	Avg. Estimated population size (plant count) for 2012-2013
Tier 1: Early detection/ Rapid response					
Microstegium vimineum	Japanese stiltgrass	10	3.4%	101-1000	1652
Ranunculus ficaria	Lesser Celandine	10	3.4%	n/a	n/a
Cynanchum louiseae	Black Swallow-wort	0	0	0	0
Butomus umbellatus	Flowering Rush	0	0	0	0
Heracleum mantegazzianum	Giant Hogweed	0	0	0	0
Tier 2: Assess as Needed					
Acer platanoides	Norway Maple	29	9.7%	1 - 10	110
Ailanthus altissima	Tree of Heaven	9	3.0%	1 - 10	22
Lonicera japonica	Japanese Honeysuckle	74	24.8%	11- 50	1342
Lythrum salicaria	Purple Loosestrife	12	4.0%	1 - 10	55
Aegopodium podagraria (ground-cover)	Bishop's Goutweed	10	3.4%	51-100	529
Celastrus orbiculatus	Asian Bittersweet	43	14.4%	11 – 50	885
Torilis sp.	Hedgeparsley	28	9.4%	1 - 10	121
Conium maculatum	Poison Hemlock	12	4.0%	11 - 50	153
Rhamnus cathartica	Common Buckthorn	21	7.0%	1 - 10	88
Berberis thunbergii	Japanese Barberry	222	74.5%	11 - 50	4636
Alnus glutinosa	European Alder	4	1.3%	1 - 10	11
Dipsacus laciniatus	Cut-leaf Teasel	4	1.3%	1 - 10	22
Elaeagnus umbellata	Autumn Olive	22	7.4%	1 - 10	77
Lonicera maackii	Amur Honeysuckle	142	47.7%	11 - 50	2928
Euonymus fortunei	Wintercreeper	25	8.4%	11 - 50	610

Tier Level	Species	# of plots	%plots with species	2012-2013 Average # of plants range	Avg. Estimated population size (plant count) for 2012-2013
Tier 3: Presence is of Interest					
Convallaria majalis (ground-cover)	Lily of the Valley	6	2.0%	1 – 10	17
Coronilla varia (ground-cover)	Crown Vetch	36	12.1%	11 – 50	793
Eleutherococcus pentaphyllus	Five-leaf Aralia	0	0	0	0
Pachysandra terminalis (ground-cover)	Japanese Pachysandra	15	5.0%	51 – 100	604
Philadelphus coronarius	Mock Orange	1	0.3%	n/a	n/a
Pulmonaria officinalis (ground-cover)	Lungwort	0	0	0	0
Rubus phoenicolasius	Wineberry	2	0.7%	n/a	n/a
Iris pseudacorus	Yellow Flag Iris	7	2.3%	11 – 50	31
Ornithogalum umbellatum	Star of Bethlehem	0	0	0	0
Viburnum opulus var. opulus	European Cranberry	53	17.8%	1 - 10	193
Viburnum plicatum	Doublefile Viburnum	10	3.4%	1 - 10	39
Tier 4: Widespread and abundant					
Alliaria petiolata	Garlic Mustard	235	78.9%	11 - 50	4697
Ligustrum vulgare	Common Privet	213	71.5%	11 - 50	4240
L. morrowii, L. tatarica	Bush Honeysuckles	204	68.5%	11 - 50	4301
Phalaris arundinacea	Reed Canarygrass	93	31.2%	51 - 100	4304
Phragmites australis	Phragmites	17	5.7%	51 - 100	1057
Polygonum cuspidatum	Japanese Knotweed	40	13.4%	11 - 50	702
Frangula alnus	Glossy Buckthorn	180	60.4%	11 - 50	3691
Rosa multiflora	Multiflora Rose	282	94.6%	11 - 50	5673
Typha angustifolia, T. x.glauca	Cattails	39	13.1%	51-100	1888
Cirsium arvense	Canada thistle	100	33.6%	11 - 50	1830
Dipsacus fullonum	Common Teasel	52	17.4%	11 - 50	854
Hesperis matronalis	Dame's Rocket	72	24.2%	1 - 10	220
Vinca minor (ground-cover)	Periwinkle	53	17.8%	51 - 100	3020

Table 11. Designated size classes (1-5) for surveying the invasive plant population

of Plants
1: 1-10
2: 11-50.
3: 51-100
4: 101-1,000
5: >1,000

Species Summary

For each buffer plot a total of 15 acres are surveyed for invasive plants. Within a given sampling year, a total of 1,500 acres are searched. To date, 298 plots encompassing 4,470 acres have been searched for invasive species. Of the 44 invasive species recognized within the tier system, 35 species were identified in 2013 and 2012 while 37 species were found in 2011 in the park system.

Each species varies with respect to growth form and size which can influence our ability to determine population size. Size class is based on the number of plant stems not the size of the plant. *Typha angustifolia, T. x.glauca* and *Phragmites australis* account for the high stem counts because of the ability to form large clonal stands. These species spread from roots and rhizomes and once established form dense homogenous stands covering entire wetlands. *Berberis thunbergii,* and *Ligustrum vulgare* are woody shrubs and the size of the shrub is not taken into account. Therefore the individual stem count for these species may underrepresent the size or spread of the population. *Microstegium vimineum*, a grass, averages a size class 4 (101 -1,000 plants) while *Acer platanoides*, a tree, averages a size class 1 (1-10 plants). These size classes align with the growth form of the plants.

The top three species occurrences from 298 plots surveyed included: *Rosa multiflora, Alliaria petiole, Berberis thunbergii,* The top three species can tolerate a wide variety of growing conditions including open sun or shade, and varying moisture gradients.

Philadelphus coronaries, Rubus phoenicolasius, Iris pseudacorus, Dipsacus laciniatus have low average occurrence rates over the 3 year survey. These plants are not well established in our parks based on the PCAP survey. Six invasive species were not identified within in the PCAP plots sampled including: *Cynanchum louiseae, Butomus umbellatus, Heracleum mantegazzianum*, *Eleutherococcus pentaphyllus, Pulmonaria officinalis, and Ornithogalum umbellatum*. These plants may exist within park boundaries but have not been identified for various reasons. Plants could exist in rare populations, are only found in a specific habitat like wetlands as in *Butomus umbellatus*, or could be ephemeral with the herbaceous parts dying or gone by the time sampling takes place as in *Ornithogalum umbellatum.*

Tier System Summary

In 2011 the species in Tier 1 and Tier 4 were recorded only as present or absent. The presence of a Tier 1 species meant immediate follow up by the Invasive Plant Management Program crew therefore no population estimate was

taken. The species in Tier 4 are the widespread and abundant with known large established populations therefore specific population estimates were not taken. In 2012, all Tiers were converted to collect population estimates by providing stem count estimates.

There were 20 separate plots where a Tier 1 species was found which included population estimates from only 2 species. *Microstegium vimineum* was identified in Mill Stream (3 plots), Rocky River (2 plots), Brecksville (2 plots), South Chagrin (1 plot) and North Chagrin (2 plots), reservations while *Ranunculus ficaria* was found in Rocky River (9 plots) and Bradley Woods (1 plot) reservation. *Ranunculus ficaria* may be underreported since only the bulbils on the soil surface remain during the PCAP sampling period and may be hidden under leaf litter.

The three species with the greatest plot occurrences and largest stem counts in Tier 2 are: *Berberis thunbergii* (222 plots), *Lonicera maackii* (142 plots), and *Lonicera japonica* (74 plots). These species have a more widespread occurrence with population sizes closer the species in Tier 4. Identifying large occurrences of these Tier 2 species may indicates the need for a reassessment of their tier placement and more active management to reduce the source potential of their populations.

Tier 3 includes species whose populations are currently being inventoried due to the limited known geographical information available. *Viburnum opulus var. opulus* (53 plots) and *Coronilla varia* (36 plots) were the most common occurring species from Tier 3. In estimated population size for 2012-2013, a clonal species, *Coronilla varia* (793 plants) was the most amount plant in Tier 3. These frequencies indicate that some of the Tier 3 species have established populations and may be poised to begin spreading throughout Cleveland Metroparks.

Tier 4 plants had the highest average invasive plant population from the PCAP buffer plot survey. Their widespread presence confirms their current management strategy (Table 9). The average class size for species abundance ranges from a class 1-3. These plants are currently under active management to reduce populations.

Trails

In 2011, we expanded our trail survey data to record more detailed information about the specific type of trail. One of the objectives was to determine the prevalence of unsanctioned or bootleg trails across the Park District. Table 11 shows the number of plots with each trail type encountered 2011-2013 and the total amount of trails encountered 2011-2013.

Table 12. Trail type distribution plots had identified trails. Trail types included APT, bridle, and sanctioned as well as unsanctioned (bootleg), deer, and road.

Trail Type	APT	Bridle	Sanctioned	Unsanctioned	Deer	Road
2013 32 plots	0	2	8	9	16	0
2012 29 plots	2	2	2	8	14	2
2011 33 plots	1	3	2	11	17	1
Total 94 plots	3	7	12	28	47	3

Overall the three years of recorded trail data showed approximately 32 percent of the plots sampled have some type of trail. Approximately half of the trails were identified as deer trails in the survey. Deer tend to repeatedly use the same corridors for movement throughout the park. These single track paths are obviously worn which can make them duel use and susceptible for travel by park patrons as well. In addition, one third of the trails were classified as unsanctioned (bootleg) trails which were clearly used by park patrons. Unsanctioned and deer trails may be underestimated because overlap may occur between these two types of trails. Park patrons may use deer trails to navigate more easily through the parks, conversely the deer may use unsanctioned trails. Authorized trails (APT, Bridle, Sanctioned) occurred in 23 percent of the PCAP plots.

Disturbance/Encroachment

Several human related impacts including littering and encroachments were documented during sampling that potentially compromise forest integrity and community composition. Documented disturbances from 2010 to 2013 included 169 plots out of 405 or 42% had evidence of trash or debris dumping from adjacent park residents or from nearby trail usage.

Several property line encroachment issues were discovered in 2013. Property boundary encroachment was detected on 5 plots (Table 12). These include primitive deer stand, dumping of lawn material, and ATV trails. (Pictures 2, 3 and 4).

Table 13. Encroachment incidents documented during PCAP 2013.

Reservation	Plot #:	Type of Encroachment:	CM Impact
Bedford	1315	Residential boundary	Primitive deer stand
Bedford	1367	Residential boundary	Grass clippings and rolls of rusted fence
Big Creek	3500	Residential Boundary	Dumping of trash, lawn materials
Bradley Woods	1306	Residential boundary	Heavily used ATV trials
South Chagrin	1400	Residential boundary	Dumping of woody debris

Terrestrial VIBI

Ten additional plots were surveyed in 2010 by PCAP staff to begin development of a Terrestrial Vegetation Index for Biotic Integrity (Terrestrial VIBI). Additional, one plot in 2011, one plot in 2012, and two plots were surveyed for the Terrestrial VIBI. This project will develop an index to rank or score upland plant community types similar to IBIs developed for wetlands.

Bike Trail Vegetation Assessment

The first designated bike trail opened in June 2012 at Royalview Picnic area in Mill Stream Run Reservation. Prior to the trail's official opening, members of the PCAP crew conducted a vegetation survey along the trail. Two 1m x 1m plots were sampled every 50m along the trail. Two plots were located on the same perpendicular line to the trail with one plot was just off the trail and the second plot 5 m off the trail. Each set of plots was randomly assigned to the left or right of the trail. The purpose of this survey was to obtain baseline data of the vegetation along the bike trail. In August 2013, a second sampling event was conducted to assess the condition and vegetation along the mountain bike trail. The results for the mountain bike trail are still being compiled and will be reported soon.

Acacia Reservation

Acacia reservation acquired in 2012 was a former golf course for over 50 years. Prior to any restoration effort, a baseline vegetation survey of 40 points was sampled in July 2013 with PCAP seasonals, the Vegetation Research Coordinator, the Plant and Restoration Ecologist, the Wetland Ecologist and the two Wetland ecologist seasonals. (See Picture 5)

Picture 2. Plot 1315 – Bedford Reservation – Primitive deer stand.

Picture 3. Plot 1367- Bedford Reservation – Adjacent residents dumping lawn debris and rolls of fence.

Picture 4. Plot 1306 – Bradley Woods Reservation – Adjacent resident created and using ATV's within the park boundaries.

Picture 5. Representative photo of the Acacia reservation vegetation sampling

Research Collaborations

In an effort to build relationships with surrounding academic institutions, several research collaborations have been initiated using the PCAP experimental design and data. These collaborations provide Cleveland Metroparks assistance with expanded data analysis. Results of such collaborations reveal patterns in ecological processes which can be used by the Division of Natural Resources to modify land management techniques to optimize ecosystem functioning. Outlined below are five different research collaborations.

Invasive Worm Survey

In collaboration with Cleveland State University, the 2010 seasonal crew assisted in a preliminary assessment of exotic, invasive worms across the Park District. The objectives of the project are to 1) locate existing worm populations within reservations, 2) identify species present, and 3) determine if correlations exist between plant community variables and invasive worm distribution (long-term). This project was initiated in mid-September 2010 after plant community data collection for PCAP was completed and lasted approximately 4 weeks. Using the original PCAP vegetation plots, a subset of 64 plots were selected for worm sampling using the mustard extraction method described by the Great Lakes Worm Watch (http://www.nrri.umn.edu/worms/research/methods_worms.html accessed 17 December 2010) and first developed by Gunn (1992).

Worm samples are currently being identified to species at Cleveland State University. Because of low rainfall during the months leading up to the sampling, soil conditions were not optimal for worm extraction; therefore, plots with no worms detected are not necessarily free from exotic, invasive earthworms.

Insect Survey of Beech Maple Communities

The Ohio State University has developed a project to measure the diversity and abundance of insects present within the Cleveland Metroparks. University researchers used the Generalized Random Tessellation Stratified Survey design (GRTS) to evaluate beneficial insect diversity, abundance and activity within Beech/Maple communities. The objectives of the project are to 1) measure the diversity and abundance of predatory insects, 2) examine the intensity of arthropod predatory activity these insects support both above-ground and at the soil surface, 3) determine the guild of predators and pollinators supporting predation and pollination within the Cleveland Metroparks reservations, and 4) measure the influence of plant diversity and complexity (measured using VIBI and FQAI), forest area, perimeter-to-area ratio, distance of plot from forest edge, and the surrounding landscape on beneficial insect communities and the ecosystem services they support within urban forests. This study used approximately 30 PCAP plots from 2010 that were designated as Beech/Maple community.

Beech Genetics

Hiram College along with Middle Tennessee State University initiated a project investigating the genetic structure of beech trees titled: Comparing asexual (clonal) and sexual (seed) reproduction of American beech (*Fagus grandifolia*) in disturbed and undisturbed sites. This project seeks to compare clonal reproduction to seed reproduction after the trees have been exposed to beech-bark-beetle disease. The goal is to determine genotype changes within beech populations before and after experiencing the disturbance caused by beech bark disease.

The initial study selected three beech maple plots in North Chagrin from the 2010 PCAP sampling year. Seasonal crew members assisted in diagramming the location of beech trees in the plot and collecting four to six beech leaves from each mature tree and from saplings larger than 3 cm in DBH. The leaves were placed small plastic whirlpac bags containing silica sand to dry the leaves for future laboratory DNA extraction and analysis.

Invasive Plants

Case Western University is using the PCAP data to examine how environmental heterogeneity relates to community invisibility. The researcher will examine the role of heterogeneity in both aboveground and belowground abiotic conditions on plant diversity to determine if heterogeneity in light availability and substrate characteristics similarly affect invasion or do these components of heterogeneity interact.

Secondly, theory predicts that both the arrangement of resources and the overall level of resources available in a community will promote invasion success but the relative contributions of each are rarely considered, which would be informative for management of invasions to establish if environmental heterogeneity or overall resource availability is a greater contributor to community invisibility.

The Case Western University project focuses on forested community plots from 2010 and 2011. The project will use richness and abundance of nonnative species to estimate "invasibility" and examine the responses for all nonnatives as well as those plants classified as highly invasive. The processes for determining presence and abundance of established versus actively spreading species are likely to differ.

Ohio EPA Soil Survey

The Ohio Environmental Protection Agency is conducting a study to evaluate the background metal concentrations in Cleveland-urban soils. Several PCAP plot locations were used for soil extraction as part of a county-wide study. The analyses performed provide the background reference concentrations of selected metals necessary for comparison. Ohio EPA is trying to determine the concentrations of selected metals that industrial and commercial facilities can use to meet regulations.

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Appendix 1: Modified U.S. National Vegetation Classification System developed by Nature Serve.

A	**OAK FOREST AND WOODLAND**		**N**	**FOREST SEEPS**						**08**	Dogwood thicket		**Z**	**Human Structures**					
	01	Dry Oak forest and Woodland		01	Skunk cabbage seep					09	Other (specify dominants)			01	Buildings and Other Structures				
	02	Dry-Mesic Oak Forest and Woodland		02	Skunk cabbage-sedge seep					10	Skunk cabbage-sedge seeps			02	Parking Lots				
B	**NORTHERN (hemlock)-HARDWOOD FOREST**			03	Sedge seep (e.g. Carex bromoides)		**V**	**Farming and Forest Harvesting**							a	Paved			
	01	Hemlock forest		04	White pine bog			01	Active Farming						b	Unpaved			
	02	Hemlock-hardwood forest	**O**	**TAMARACK FORESTS**					a	Upland Farm Field				03	Roads and Trails				
C	**BEECH-MAPLE FOREST**			01	Tamarack bog				b	Converted Farm Field (Hydric Soils)					a	Paved			
	01	Beech forest		02	Tamarack-hardwood bog			02	Hayfield						b	Unpaved			
	02	Beech-maple forest		03	Tamarack fen				a	Upland Hay Field									
	03	Sugar maple forest	**P**	**GL WOODED DUNE-SWALE**					b	Converted Hay Field (Hydric Soils)									
	04	Beech-red oak forest	**Q**	**FRESHWATER MARSH**					c	Wet Hay Field									
D	**"MIXED" FORESTS**			01	Submersed marsh			03	Pasture										
E	**MESOPHYTIC FOREST**			02	Floating-leaved marsh				a	Active, High Intensity									
F	**PINE-OAK ROCKY WOODLAND**			03	Mixed emergent marsh				b	Active, Low Intensity									
G	**GLADE, BARRENS-WOODLAND**			04	Cattail marsh				c	Passive									
	01	Dry Acidic Glade and Barrens		05	Phragmites marsh			04	Old Field										
	02	Alkaline Glade and Woodland	**R**	**WET MEADOW**					a	Young (<5 years)									
	03	Calcareous Glade and Barrens		01	Fens				b	Middle (5-10 years)									
H	**OAK SAVANNA-BARRENS**				a	Cinquefoil-sedge fen			c	Old (>10 years)									
	01	Interior (deep soil) Oak Savanna			b	Tussock sedge fen		05	Post Clearcut Communities										
	02	Oak Barrens			c	Carex trichocarpa fens			a	Young (<5-10years)									
I	**PRAIRIE (upland)**			02	Wet Prairie				b	Middle (10-25 years)									
	01	Dry-Mesic Prairie			a	cordgrass-bluejoint slough			c	Old (>25 years)									
	02	Mesic Prairie			b	bluejoint-muhly slough		**W**	**Atypical Successional Woody Communities**										
	03	Wet-Mesic Prairie			c	prairie (southern) sedge meadow			01	Upland Forests									
	04	Oak Opening Sand Prairies				(*C. atherodes, C. lacustris, C. stricta*)			a	Cottonwood Thickets and Woodland									
J	**CLIFF AND TALUS**			03	Sedge meadow				b	Ash Thickets									
	01	Acidic Cliff and Talus			a	lake sedge meadow			c	Planted (Specify)									
	02	Calcareous Cliff and Talus			b	hyaline sedge meadow			d	Red Maple Thickets and Woodland									
	03	Circumneutral Cliff and Talus			c	wool-grass meadow			e	Other (Specify)									
	04	Acidic Cliff and Rockhouse			d	*Carex trichocarpa* meadow		02	Upland Shrub Thickets										
K	**GL SHORE-CLIFF-DUNE-ALVAR**				e	successional sedge meadow			a	Dogwood Thickets									
	01	Acidic Rocky Shore and Cliff				(*C. vulpinoidea, scoparia, tribuloides,*			b	Prickly-Ash Thickets									
	02	Alkaline Rocky Shore and Cliff				*cristatella, lurida)*			c	Blackberry Thickets									
	03	Alvar		04	rice-cutgrass meadow				d	Other (Specify)									
	04	Dune		05	reed canary grass meadow		**X**	**Disturbed Soil Communities**											
L	**FLOODPLAIN FOREST (UPLAND)**			06	other wet meadow (specify dominants)			01	Slag Barrens										
	01	Mesic Floodplain Forest		07	Wet-Mesic Lake Plain Prairie			02	Landfill										
	02	Cottonwood Forest			a	Twigrush meadow		03	Urban Vacant Land										
	03	Sycamore Woodland			b	Weak sedge meadow		04	Recently Graded Soils										
M	**WET FLATWOODS (inc. vernal pools)**				c	Northern bluejoint meadow		05	Abandoned Mine Land										
	01	Swamp white oak		08	Skunk cabbage-sedge seeps			06	Reclaimed Mine Land										
	02	Pin oak flats	**S**	**Natural Lakes and Ponds (>2 m deep)**				07	Other (specify)										
	03	Maple-Ash-Elm forest	**T**	**Streams and Rivers**			**Y**	**Pond and Reservoir**											
	04	Maple-Ash swamp		01	Flowing water			01	Stormwater Pond										
	05	Ash-elm swamp		02	Exposed sediment (gravel bar)			02	Farm Pond										
	06	Oak-Maple swamp	**U**	**Shrub Swamp**					a	Young (<10 years)									
	07	Black ash swamp		01	Tall shrub fen				b	Middle (10-50 years)									
	08	Green ash swamp		02	Leatherleaf bog				c	Old (>50 years)									
	09	Pumpkin ash swamp		03	Tall shrub bog			03	Reservoir										
	10	Mixed swamp forest		04	Buttonbush swamp				a	Small (<25 ac)									
	11	Cottonwood Forest		05	Alder swamp				b	Medium (25-50 ac)									
	12	River birch swamp		06	Mixed shrub swamp				c	Large (>50 ac)									
	13	Other (specify dominants)		07	Willow thicket														