



Systematic Rare Plant Survey at the Cuyahoga Valley National Park

Final Report (Public Version)

Natural Resource Report NPS/CUVA/NRR—2023/2573



ON THE COVER

Showy Orchid (*Galearis spectabilis*), one of the rare plants found at Cuyahoga Valley National Park during this project.
NPS

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Executive Summary

EnviroScience completed a systematic rare plant survey in the Cuyahoga Valley National Park (CUVA). CUVA staff use the visitor use management planning (VUMP) process to draft proposed management zones for the park to track resource degradation and guide management decisions. The VUMP process has identified a critical need for a park-wide rare plant inventory to supplement outdated surveys conducted from 1986 to the early 2000s. This systematic transect-based survey was designed to provide current rare plant data to inform the VUMP process.

These updated rare plant data will support the National Park Service (NPS) in their efforts to:

- Prioritize ongoing conservation efforts.
- Support and improve the quality of the VUMP products and validate the proposed management zones.
- Support early stages of Comprehensive River Management Planning.
- Inform ongoing management decisions in sometimes contentious areas of the park.
- Help prioritize ongoing management efforts.

Field surveys consisted of 10-meter-wide belt transect surveys conducted throughout all portions of the park. Transects were aligned with previous 400-m transects from the park's invasive plant survey (Morgan et al. 2018), supplemented by additional parallel transects placed 200m from the original transects. For high priority areas identified by NPS, additional meander surveys were completed to increase the total area surveyed to ten percent of these areas. Meander surveys were often routed to pass through or near historic locations of rare species, ensuring that historic rare plant locations were visited.

A total of 98 species and 675 rare plant locations were inventoried during the survey. Of the 23 surveyed management zones, A-P North Sensitive Resources, Virginia Kendall High Value Experience and Blossom Woods Natural zones had the highest number of rare plant records while those zones with fewer records had relatively high population size and densities. Invasive species were dominant in Virginia Kendall High Value Experience and Blossom Woods Natural zones in locations where rare plants were found. Among management zones, no discernible variation in habitat and disturbance-based measures was observed. Most zones were characterized as containing some levels of human disturbance, earthworm infestation and deer browsing effects colocated with rare plants. Correlations among population and species-based parameters did not show any clear positive or negative associations with the exception of a weak positive relationship between areal percent cover of rare species and percent cover of invasive species. Patterns of negative but weak correlations were observed between earthworm infestation, deer browsing and density and cover of rare species. Results from canonical correspondence analyses showed that the vegetation type was one of the most important factors in structuring rare plant assemblages with floodplain and oak dominated habitats showing strong associations with groupings of rare species.

Additional surveys in multiple seasons are recommended. Future efforts should include more robust and intensive sampling in areas with high concentrations of previous records, higher concentrations of 2021 occurrences, and unique, high-quality habitats within the park. Although systematic sampling using belt transects allows for repeatable coverage across the entire park, meander surveys, those less repeatable over time, may further prove to be beneficial in identifying rare plants.

Introduction

The Cuyahoga Valley National Park (CUVA), located in northeast Ohio, is a regional treasure encompassing 33,000 acres between Cleveland and Akron, Ohio. CUVA provides a unique blend of natural resources and cultural, historical, and recreational opportunities. In part due to the strains caused by these sometimes-conflicting uses and increased visitation, CUVA uses a variety of tools to guide and protect its natural and cultural resources. Since 2018, CUVA has used visitor use management planning (VUMP) to draft proposed management zones for the park to track resource degradation and guide management decisions (Table 1; Figure 1). The VUMP process has identified several critical data gaps, including the need for a park-wide rare plant inventory to supplement outdated surveys conducted from 1986 to the early 2000s. This systematic transect-based survey was designed to provide current rare plant data to inform the VUMP process.

Table 1. Total Size of all delineated management zones at CUVA.

Management Zone	Size (acres)
Adams Run Natural Zone	1329
A-P North Sensitive Resources Zone	1437.1
Bath Road to Peninsula River Corridor Zone	1463.2
Blossom Woods Natural Zone	2896
Blue Hen Falls Natural Zone	136.7
Boston Mills Historic District Zone	31.5
Botzum Natural Zone	789.9
Canal Cultural High Value Experience Zone	302.1
Coliseum Natural Zone	323.9
Columbia Sensitive Resources Zone	715.6
Everett Cultural High Value Experience Zone	1580
Furnace Run South - Oak Hill Natural Zone	4205.3
Interstate Natural Zone	142.3
NA—outside management zones	5353.3
Northern Natural Zone	1328.6
Old Carriage Natural Zone	701.2
Peninsula High Value Recreation Zone	155.7
Peninsula to Boston Mills River Corridor Zone	196.9
Pinery Narrows/Twin Sisters Sensitive Resource Zone	348.9
Snowville Woods Natural Zone	2138.2

Table 1 (continued). Total Size of all delineated management zones at CUVA.

Management Zone	Size (acres)
Stanford Run /Hines Hill High Value Experience Zone	2173.6
Station Road to Boston Mills River Corridor Zone	842.1
Station Road to Rockside River Corridor Zone	740.9
Terra Vista Natural Zone	264
Twin Sisters-Mudcatcher Sensitive Resource Zone	232.8
Virginia Kendall High Value Experience Zone	2889.4
Total	32,718.20

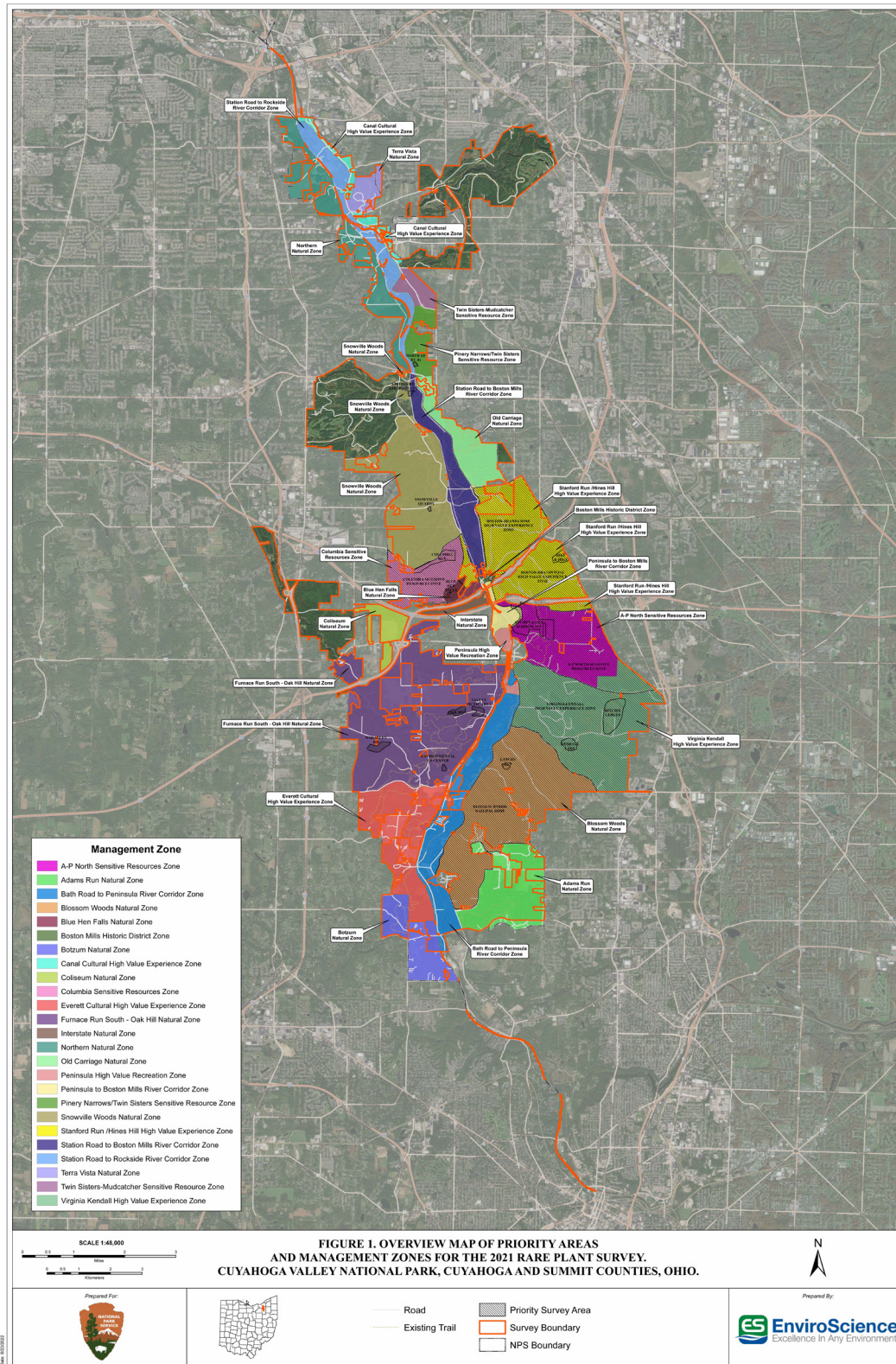


Figure 1. Overview map of priority areas and management zones for the 2021 rare plant survey.

These updated rare plant data will support the National Park Service (NPS) in their efforts to:

- Prioritize ongoing conservation efforts.
- Support and improve the quality of the VUMP products and validate the proposed management zones.
- Support early stages of Comprehensive River Management Planning.
- Inform ongoing management decisions in sometimes contentious areas of the park.
- Help prioritize ongoing management efforts.

The 2021 rare plant survey was designed to cover the entire park which totals nearly 33,000 acres, including several properties remaining in private ownership (Figure 2; Table 2). The survey built on the earlier work of Barbara Andreas, Ph.D., and others and included recent acquisitions such as the 2,900-acre Blossom tract. Since the time of the Andreas survey (circa 1986), rare plant areas identified by Andreas have been re-surveyed, and incidental records by local botanists have documented new areas of interest. However, none of these follow-up surveys have been conducted systematically. Of particular concern, follow-up surveys often failed to relocate rare plant populations identified in 1986 or suggested that reduced abundance may be due to visitor impacts. The expansion of invasive species within park boundaries such as garlic mustard, Japanese stiltgrass, and Japanese knotweed place increased pressure on these sensitive areas and populations.

CUVA is a relatively new addition to the NPS system, established first as a National Recreation Area in 1974 and then as a National Park in 2000. Despite its recent entry to the NPS system, the area has served a variety of functions for residents of northeast Ohio since prehistoric times. From Native Americans to early settlers of the Western Reserve to urban populations of the present day, people have long drawn on the rich resources of the Cuyahoga River for a variety of uses. Over centuries, these varying uses have left their imprint on the area now managed by CUVA. The ongoing preservation of its rich cultural, historical, and natural resources must be balanced with the general public's desire to use and enjoy the park. Even without the pressures imposed by visitors, its location between the sprawling metropolitan areas of Cleveland and Akron impacts the park in numerous ways, including air and water pollution, excess erosion caused by urbanization and poor stormwater management practices, and even legacy hazardous waste sites. The combined environmental stressors resulting from increased usage, hydrological changes caused by upstream dam removal projects, and the continued onslaught of invasive plants and animals make it all the more urgent that NPS planners have current inventories of the park's natural resources, including its rare and threatened plants. It's impossible to protect these critical resources for future generations if they aren't periodically assessed.

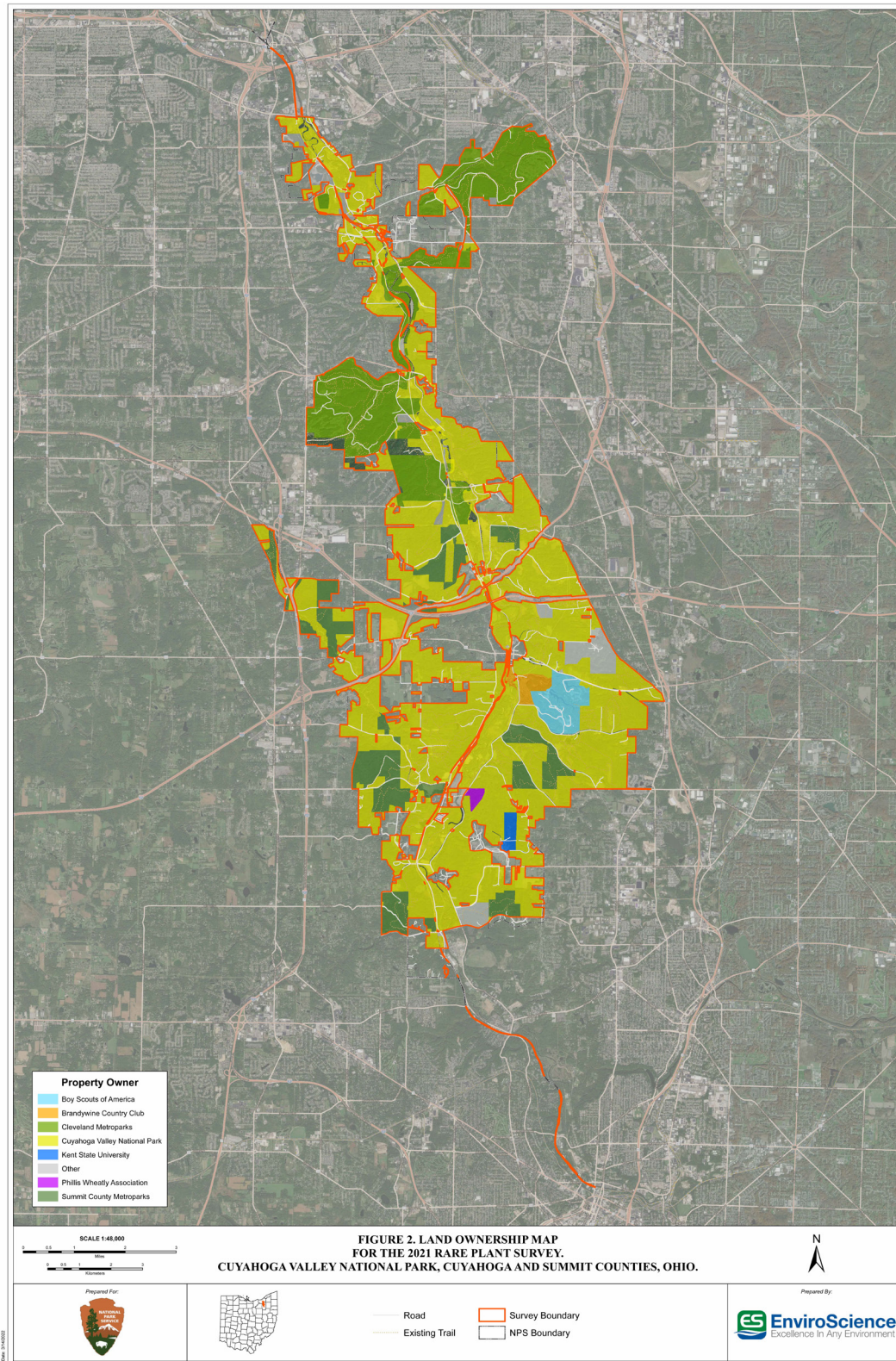


Figure 2. Land ownership map for the 2021 rare plant survey.

Table 2. Property Owners in Addition to the National Park Service.

Landowner	Locations	No. of Polygons	Total Area (ac)	No. of Historic Records	No. of Records 2021 Survey
Kent State University	Various	5	126.8	1	2
Cleveland Metroparks	Various parks	14	4,715.00	144	43
Metroparks, Serving Summit County	Various parks	37	2,643.80	102	43
Girl Scouts of Northeast Ohio	Camp Ledgewood	4	360.3	9	29
Boy Scouts of America	Camp Manatoc	4	584.1	3	13
Phyllis Wheatley Association	Camp Mueller	2	61.4	0	3
Brandywine Golf Club	Brandywine Golf Course	2	202.9	2	2

History of Rare Plant List at CUVA and Development of “Active List” for Inventory

An initial inventory of vascular plants of Cuyahoga Valley National Park (formerly Cuyahoga Valley National Recreation Area) was conducted by Barb Andreas in 1986 (Andreas 1986). Andreas documented over 800 species including 51 state-listed rare species (Endangered, Threatened or Potentially Threatened). No federally listed species have been known to occur within the Park. These 51 state-listed species made up the original “rare plant list” used by resource managers at CUVA. The original state list was created by Ohio Department of Natural Resource (ODNR) in 1980 and has changed significantly since its inception; the state now updates its list biennially to reflect changes in plant populations and the knowledge of occurrences throughout the state. In 1999, the Park developed the “Rare Plant Monitoring Plan” (1999) with an updated rare plant list by removing species that were no longer state listed and adding any species known to occur in the park that had since been added to the ODNR list to create what will be referred to as the “active list”. This plan was followed up by a 2003 survey of rare plants focused on invasive species in “rare plant areas” which were delineated at some point following the Andreas survey. Despite the plan suggesting monitoring every 5 years, unless obvious threats to populations are observed, there has been limited follow up and the Rare Plant Monitoring Plan was largely abandoned.

Rare plants once again gained the attention of park staff in 2016 when developing a “Fundamental Resource Map” to guide the park through critical planning efforts, including zoning of park lands as well as Visitor Use Management and Comprehensive River Management planning. While the records from past survey efforts had been incorporated into the park’s GIS files, these data needed significant curation and most records had not been revisited or confirmed for decades. The Park was able to fill in some of the data gaps using the Ohio Natural Heritage Database records and the tremendous information gained and curated by biologists from the local park districts. Summit Metro Parks (SMP) and Cleveland Metroparks (CMP) own and manage land within the congressional boundary of

CUVA and the Park has benefited tremendously from the work of their Biologists/Botanists Rob Curtis (SMP) and John Reinier (CMP). Despite these rich resources, park staff still felt the information on rare plant distribution throughout the park had major gaps and identified the need for targeted surveys, or better, a parkwide inventory of rare plant species.

Through the National Park Service Inventories program CUVA was able to get a parkwide rare plant survey funded that would be conducted during the 2020 field season. Based on conversation with local and regional botanists, the Park decided to break the mold of the previously used “active list” at CUVA. While all state listed species remained on the list, conversations with local and regional botanists made clear the need to develop a list that goes beyond state listed species. This opinion was further emphasized during the 2019 Wild and Scenic River Eligibility Study where regional botanists highlighted numerous species and plant communities that were not listed, but rare at a regional scale. The Park and partners ultimately determined the Cuyahoga River at CUVA had an Ecology/Botany Outstandingly Remarkable Value driven by both state-listed and regionally rare species. While the use of political boundaries in conservation is often controversial and counterproductive, including regionally rare species on the “active list” is essential for regional conservation of biodiversity and fulfillment of the NPS mission.

To develop an “active list” for the 2020 survey CUVA Biologist Ryan Trimbath and Heartland Inventory and Monitoring Wetland Ecologist Sonia Bingham recruited regional botanists Rob Curtis and John Reinier to help. Individually, they tracked plants in their parks (SMP & CMP) and developed schema for ranking rarity within their network. Additionally, they had both begun working independently on a list for the Lake Erie Alleghany Plateau (LEAP) region. Working on the list for CUVA was the first step in developing a formal list for the LEAP region. Development of the list also considered NatureServe global ranks, which justify inclusion of species like *Juglans cinerea* which has a G3 (Globally Vulnerable) status despite being locally stable. A number of species that are locally rare and are poaching targets were also included, such as orchids (i.e., *Platanthera orbiculata* and *Cypripedium acaule*) and ginseng (*Panax quinquefolius*), all three of which were state listed at the time of Andreas survey. With no federally listed species, state listed species remain at the core of the “active list”, including all state listed species known to be present, historically present or may be present based on expert opinion.

The “active list” used in the 2020 EnviroScience survey was developed through a series of correspondences with multiple iterations exchanged between Curtis, Reinier, Bingham and Trimbath. The final list was sent to EnviroScience prior to the 2020 field season and includes 169 total species (45 state listed and 124 regionally rare/species of special interest; Appendix A). The list continued to evolve through the field season allowing for species to be dropped if they were showing to be more common than expected based on field observations. Additionally, species were added to the list during the field season as unique/rare species were discovered. The list will continue to evolve as species status changes biennially and new species are discovered. Following receipt of the final rare plant survey report and deliverables, NPS will critically evaluate the official “active list” for long-term monitoring and management.

Methods

Literature Review and Stakeholder Queries

CUVA staff provided a list of target plant species prior to initiation of field work (Appendix A). EnviroScience reviewed available rare plant data from the following sources:

- Internal CUVA rare plant GIS data
- Summit County Metroparks
- Cleveland Metroparks
- The Ohio Department of Natural Resources, Division of Natural Areas and Preserves Natural Heritage Database

Information gathered during these inquiries were used to inform the field crews of historic records on or near transects and allowed meander surveys to be strategically placed within the priority areas. A total of 739 rare plant records were compiled from these sources.

Coefficient of Conservatism (C of C) values for the plant species on the survey list were obtained from the Ohio Vascular Plant Database (Andreas et. al .2004). Andreas et. al. describe the C of C as, “a numeric score from 0 to 10 assigned to each plant species growing in a specified geographic region,” in this case, the State of Ohio. A low C of C score indicates that a species tolerates a wide range of habitats and ecological conditions. A high C of C score indicates that a species has narrow habitat requirements.

Written or verbal permission was obtained from non-National Park Service landowners prior to accessing their respective properties. Permission sheets and permits were carried by field crews at all times.

CUVA staff also provided a list of high priority areas to receive intensified survey coverage. These areas include 14 Unique Habitat Areas and 5 Management Zones. For the sensitive resource zones, NPS wanted more coverage to help justify the “sensitive” designation. NPS expects the High Value Experience Zones to require a higher level of protection and monitoring in areas with rare plants, so coverage was increased to increase the likelihood of finding any rare plants. The Blossom Woods Natural Zone received additional survey coverage because the Blossom tract was recently acquired and had not been previously surveyed.

Unique Habitat Areas:

- Langes Run
- Kendall Lake
- Ritchie Ledges
- Stumpy Basin Borrow Pit
- Bike & Hike
- North of Rt. 82

- Station Rd Railroad Cut
- Snowville Quarry
- Columbia Run
- Blue Hen Falls
- Valley Picnic Area
- Oak Hill
- Environmental Ed Center
- Wheatley Rd

Proposed Management Zones:

- Boston-Brandywine High Value Experience Zone
- Virginia Kendall High Value Experience Zone
- Columbia Sensitive Resources Zone
- A-P North Sensitive Resources Zone
- Blossom Woods Natural Zone

Field Surveys

Field surveys began on April 7, 2021 and continued through September 30, 2021. Fieldwork in different habitats was timed to coincide with peak bloom times as much as possible.

Survey Transect and Meander Design

Field surveys consisted of 10-meter-wide belt transect surveys conducted along grid lines throughout all portions of the park (Figure 3). To place the survey transects, a 200-meter by 200-meter grid was first overlaid on the entire park. The grid aligned with transects from the previous invasive plant survey (Morgan et al. 2018), which were spaced at 400m intervals. The 400-meter transect spacing from the 2018 survey provided insufficient coverage of the park, therefore, additional lines were placed between the 2018 lines to arrive at the final spacing of 200 meters. Transect lines were placed on gridlines parallel with one axis, while transect start/end points were placed at gridline intersections. Each transect was 400m long, unless interrupted by property lines or the study area boundary. Transect spacing was consistent throughout the park, not weighted by priorities.

For the high priority areas identified by NPS, additional meander surveys were completed to increase the total area surveyed to ten percent in high priority areas (Figure 4). Meander surveys were often routed to pass through or near historic locations of rare species. This method ensured that historic rare plant locations were visited. Some meander surveys were routed through potentially suitable habitat identified in the field even if no historic records were present. A summary of transect characteristics is contained in Table 3.

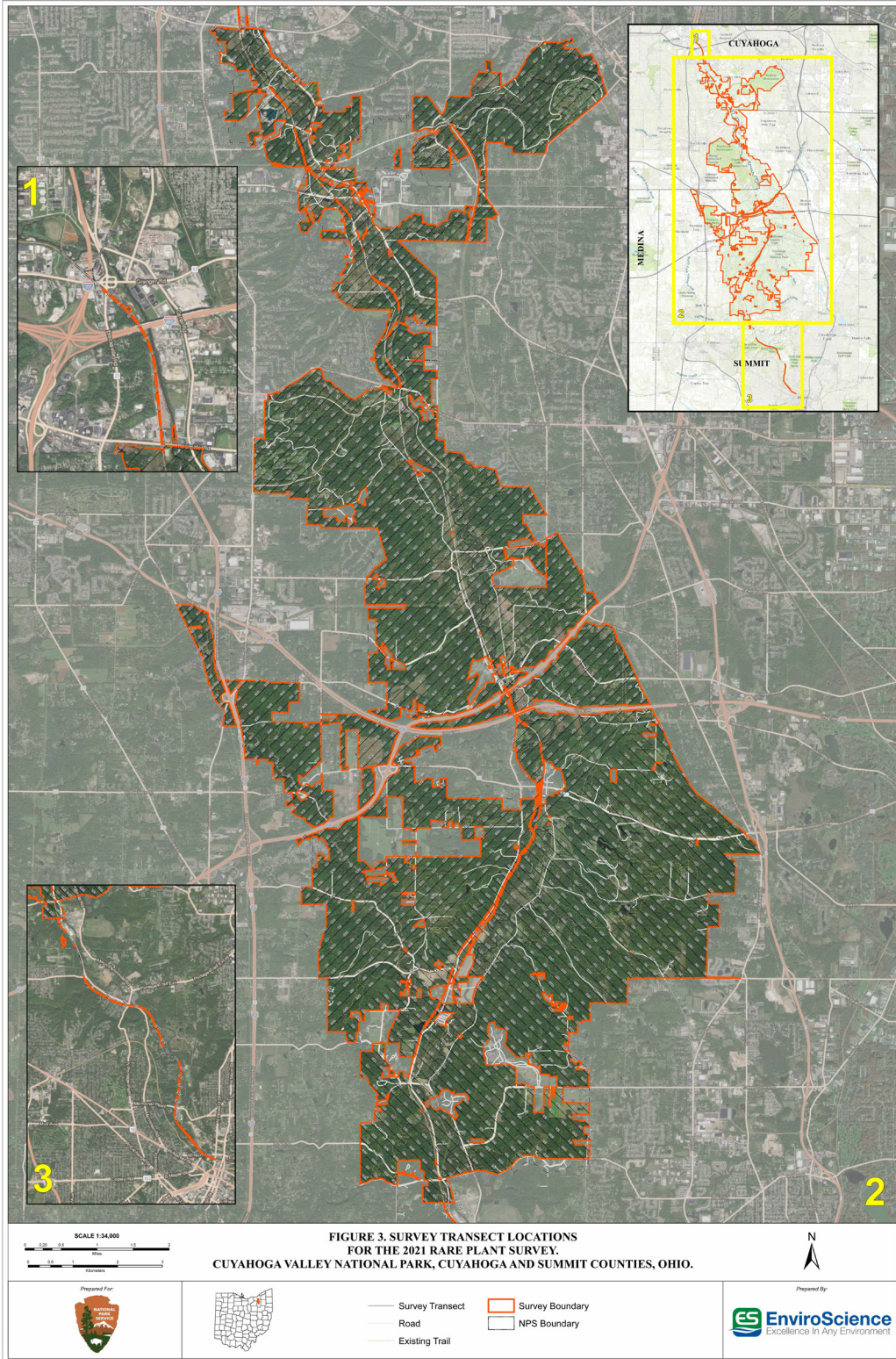


Figure 3. Survey transect locations for the 2021 rare plant survey.

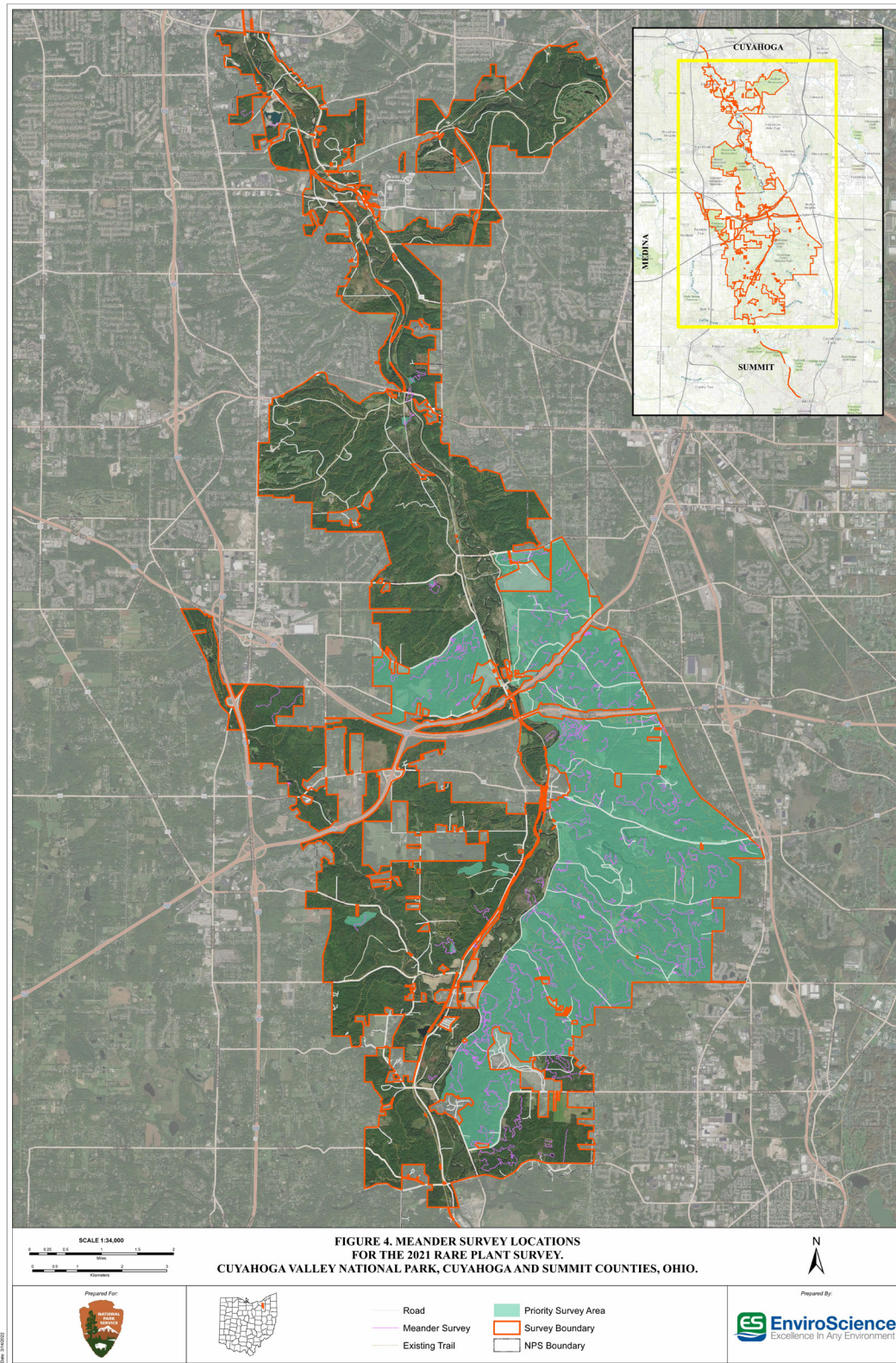


Figure 4. Meander survey locations for the 2021 rare plant survey.

Table 3. 2021 CUYA Rare Plant Survey Transect Characteristics.

Survey Type	Transect	Meander
Length	400m ^A	Various (approx. 400m)
Width	10m	10m
Total Area per Transect	4,000 m ²	Approx. 4,000–5,500 m ²
Number Completed	1782	369
Total Area	1,443 ac.	510 ac.
No. of Revisits	182	0
Number of Transects with Rare Plants	281	76
% of transects with rare plants	16%	21%
Average Time Per Transect	1.7 hr	Not calculated
Number of Transects Completed in Priority Areas	604	328
Incidental Observations	39	–

^A Some transects that were limited by property boundaries were less than 400m long.

Survey Method

Each belt transect or meander survey was traversed on foot. A submeter-accurate GPS unit with a background file showing the center line and 10-meter buffer edges for each transect was used to navigate along each transect and to record the location of the meander surveys. Botanists walked as close to the center line as was feasible and safe, given onsite conditions, and surveyed the entire area visible from that center line. Visibility was assumed, on average, to be approximately 5 meters in each direction. Tablets were used to photograph rare plants identified during the survey. The tablets were also used to complete the daily field safety forms and contained reference materials for in-field use. More information on equipment used is contained in Table 4.

Table 4. Hardware and Software Used for Data Collection.

Equipment	Software	Used For	Comments	GPS User Manual
Trimble GeoXT, Trimble GeoXH,	TerraSync	Location data for transects and rare plants, attribute data for rare plants	This older software was used because background files with transects were loaded onto the GPS units' SD cards and were accessible without Wi-Fi connection.	GeoExplorer 2005 Series Getting Started Guide, Version 1.10. Trimble Navigation Limited, Westminster, Colorado. 2007.
Geode GNS2	ArcGIS Field Maps; Geode Connect	Location data for transects and rare plants, attribute data for rare plants	The Geode receiver was used to collect sub-meter GNSS data when paired with an iPad or tablet.	Geode Owner's Manual. Juniper Systems, Inc., Logan, Utah. 2021
Tablet—iPad or Android	FastField Forms	field safety forms, rare plant photosheet	Completed data forms automatically uploaded to a secure server when tablet had access to Wi-Fi	Used with Geode as GPS receiver. See Geode Manual (above).

Data Collection

When a rare plant was observed within the survey area, plant location data were collected using submeter-accurate GPS units. Point data were used to document single plants or small populations, while larger areas were documented using polygons. Data were collected on the GPS unit for each rare plant occurrence. No environmental data were collected at locations with no rare plants, as this was not within the scope of the project. A summary of the collected data fields and their attributes is contained in Table 5.

Table 5. Data Fields Collected for Rare Plants.

Data Field	Description
Record Number	FML_0001_LLLL#—First, Middle, Last initials of botanist—starting with 0001 all the way to 9999, sequential record number for each individual botanist—LLLL# is the USDA PLANTS species code
Species Code	USDA PLANTS species plant code
Transect Number	Transect Number
Date	Date record was observed
Observer	Surveyor's first, middle, and last initials
Number of Photos	Number of photos taken for the record
Physical Voucher	Yes/No—Default is No
Population size	Estimated number of individual stems or clumps observed at the record
Age Classes Present	SG: seedling JV: juvenile MT: mature RO: rosette SF: sterile frond (ferns only) FF: fertile frond (ferns only)

Table 5 (continued). Data Fields Collected for Rare Plants.

Data Field	Description
Density per Square Meter	Estimated number of individual stems or clumps per square meter within population
Percent Cover	Estimated percent cover (use the nearest 0.1 if below 1%). Percent cover is estimated within the entire population area, or for very small populations a 30-foot radius is assumed.
Condition	Good/Fair/Poor Good: population looks healthy with no stressors. Fair: some stressors observed such as deer browse, insect damage, or evidence of drought response. Poor: high stressor influence, population looks very unhealthy, persistence of the population may be at risk.
Flowering	Yes/No
Flower Color	One or multiple colors
Fruit	Yes/No
Fruit Development	None/Immature/Mature/Past Peak None: no evidence of fruiting. Immature: fruit still in development. Mature: some evidence of dispersal. Past Peak: fully dispersed, fruit on ground, or shriveled fruit still attached
Miscellaneous Characteristics of Plant:	Anything that is beneficial for ID purposes or unique characteristics, particularly diagnostic characters that won't be evident in the photo voucher. Use characteristics from dichotomous key(s).
Invasive Species	Up to four invasive species surrounding the rare plant record (out to approximately 30 feet for small populations).
Percent Cover:	Percent cover of invasive plant species recorded either within a 30-foot radius from small records or within the area of the rare plant population.
Human Disturbance:	None/Some/Extensive None: no evidence observed. Some: little evidence observed—litter/trash, footprints, some trampling. Extensive: a lot of evidence observed—near trail, lots of trash/litter, major trampling/footprints
Deer Browse	None/Some/Extensive/Minimal Understory None: no evidence observed at all—saplings are fully intact. Some: evidence of browse on stems/leaves of less than 50% of plants in area. Extensive: a lot of evidence—browse evident on at least 50% of individual plants, or browse line observed. Minimal Understory: minimal to no understory observed, so browse cannot be assessed.
Deer Trails	None/Some/Extensive None: none observed. Some: one trail observed. Extensive: two or more trails observed.
Earthworm IERAT:	The IERAT dichotomous key assesses earthworm populations as a score of either 1, 2, 3, 4, or 5. The IERAT was designed for assessing <i>Lumbricus</i> populations, but was also applied to <i>Amyntas</i> in this survey, ignoring references to middens within the key.
Erosion	None/Some/Extensive. Due to the different types of erosion potentially observed, these categories are subjective.

Table 5 (continued). Data Fields Collected for Rare Plants.

Data Field	Description
Erosion Description	Describe the type of erosion, stream, human, natural steep slope, etc.
Other Notes	Any other pertinent information regarding this record

Data collected included the number of individuals, stems, condition, whether plants were flowering or fruiting, and any observed pressures from invasive plant species, human traffic, deer herbivory, earthworms, or other impairments. Number of individuals reflected number of stems, or number of clumps for clump-forming graminoids and multi-stemmed shrubs. If the population size was low these were counted; for larger populations these were estimated. Population size is a mixed data value (stems and/or clumps), rather than one source type, which can over-represent density. Rare plant percent cover and data on observed pressures were collected out to approximately a 30-foot radius around the center of a smaller rare plant population, or within the bounds of the rare plant population, whichever was larger.

Photographs were taken of each rare plant record, and photo vouchers were used instead of physical voucher specimens. Data fields on the GPS units were available for botanists to document characteristics relevant for identification and verification, particularly measurements of diagnostic parts and descriptions of features that would not likely be obvious in photographs. Specimens were only collected if necessary to identify the specimen and were pressed and labeled for inclusion in the Kent State University herbarium. Voucher specimens collected included five *Carex* species and one *Dichanthelium* species. Records with only a single individual or few individuals were not physically collected.

Species Identification and Verification

All species were identified using commonly accepted botanical references, including the Field Manual of Michigan Flora, Weakley (2020), Flora of North America online, and the USDA Plants Database. Additional online sources were used as supplementary references, including Go Botany, Illinois Wildflowers (Hilty 2021), and Minnesota Wildflowers.

Species identifications were subject to an internal QA/QC procedure. At least ten percent of all rare plant identifications and any questionable identifications were double-checked by a different in-house botanist. Photo vouchers included a scale and were georeferenced so that locations can be obtained from the photo. All vouchers and photo vouchers were labeled for future use.

Training

In order to ensure the collection of high quality, consistent data, all botanists completing field work were required to undergo a training program prior to and early during their field work. The training portion for the CUVA rare plant survey consisted of the following:

- **Plant list:** A spreadsheet containing the list of species in the survey was provided to each surveyor prior to initiation of field work. Each species listing included information on family

name, endangered status, bloom time, habitat type, and 4-letter code. Additional tabs contained further information on habitat preferences, previous sighting records, and sources for images from Michigan Flora (Michigan Flora Online 2021). A copy was included on each tablet. Each botanist reviewed the sheet prior to entering the field.

- **Tablet information sheets:** Each tablet assigned to surveyors included park maps and reference information for each plant species. The three map reference sheets included transect locations within the park, priority survey areas, and land ownership within the park. Additionally, the tablets contained reference files on each plant on the rare plant list. These included dichotomous keys for genera with multiple species on the list, as well as description and images of each plant.
- **In-person equipment training:** Each botanist was trained on the protocol for utilizing the Trimble GPS units to record data. A step-by-step procedure was included on a hardcopy worksheet as well as on each tablet. The hands-on training included information on coordinate system and datum, the procedure to complete a transect, the data to be recorded, and the protocol when a rare plant is found.
- **In-person field work:** Each botanist was required to complete at least two days of sampling with two different experienced botanists before completing transects independently. During these training days, the botanist being trained used the GPS units and tablets to navigate, reference information, and collect data in order to gain hands-on experience with all equipment and protocols while they had an experienced botanist present to ensure that they were following protocols correctly. During this training, all botanists collected data for multiple rare plant records prior to working independently.
- **Historic Rare Plant Records:** Senior botanists had access to QGIS on a secure EnviroScience server to view historic rare plants records. All field botanists had a background file on their GPS units depicting points for historic rare plant record locations. Additionally, tablets contained a reference map of these historic plant record locations with each historic record given a unique identification number. Tablets also contained a spreadsheet depicting which species was located at each numbered point. This allowed each botanist to have a better understanding of which plants to search for prior to surveying a transect.

Health and Safety

Health and safety considerations were an important part of each field visit. Each field crew member was assigned a list of transects to be completed for the week. A contact list with all field, office, and client personnel's contact information, car make/model, and license plate was carried in the field and provided to NPS security in case of emergency. Each day, field personnel were required to complete and submit an Anticipated Hazard Analysis prior to completing field work. Crew members were required to check in with a designated office personnel in the morning when arriving onsite and in the evening when leaving the site.

Quality Assurance/Quality Control

In addition to the training described above, ten percent of the belt transects were re-visited by a different botanist in order to check replicability. Efforts were made to complete re-visits within a few weeks of the previous survey, with varying degrees of success. The presence of rare plant records was not evaluated prior to assigning transect re-visits in order to minimize bias. As the majority of the re-visit sites were of transects where rare plants were not encountered, their utility in measuring surveyor success was limited.

After field work was completed, all data points were evaluated by Brian Slaby, an experienced botanist. Incomplete data were noted, and incorrect identifications were removed. Records were assigned a degree of confidence (either “low,” “medium,” or “high”), which was largely based on whether documentation was sufficient to positively confirm the identification of the record. Records assigned a confidence of “low” were taxa that are unlikely to be found in the park and were not documented sufficiently enough to confirm presence, or taxa that may have a higher likelihood of being present but were very poorly documented. In some cases, documentation consisted of a single overview photo where the target plant was not recognizable. In other cases, no photo or written documentation existed at all. Records assigned a confidence of “medium” had insufficient documentation to independently verify a correct identification to a high degree of confidence, but the photos and/or written descriptions suggested that the identification may be correct. This was often the case for species with subtle diagnostic characteristics that do not show up well in photos, especially if specific measurements are required for a positive identification and those measurements were not documented. In the case of some records with poor documentation, “medium” confidence was assigned if other records of the species had been verifiably identified by the botanist in the past. Records assigned a confidence of “high” could be independently verified based on the photos and/or written descriptions. The most frequently observed and easily identified species (i.e., *Hepatica americana*) were assigned “high” confidence even if documentation was poor.

PDOP data was not required in the scope of the project, however, some of the GPS units used recorded it automatically, for approximately 30% of the rare plant records.

Plant Habitat Model

A spatial model was created using historic rare plant occurrence records and environmental variables to predict rare plant localities at CUVA. The model was intended to be used as a tool in determining optimal locations for transect surveys. Models were developed using rare plant locality data from multiple sources. Environmental covariates used for modeling were selected based upon local knowledge of ecology and factors assumed to influence plant distributions including both environmental and physical characteristics. A full description of the model is contained in Appendix B.

Data Analysis

All analyses with the exception of the Canonical Correspondence Analysis (CCA) were performed in R, version 4.2.1. The CCA was performed using CANOCO version 5.12 (ter Braak & Smilauer, 2019).

Some transects were visited twice, once for the normal survey and again on a QA/QC visit. In cases where a rare plant occurrence was recorded on both visits, each pair of records was reviewed by an experienced botanist, who flagged one record in each pair as “preferred” and the other as “not preferred.” Preference was based on whichever record had better data quality. Records marked “not preferred” were excluded from the analysis.

Although there were 682 rare plant records collected, records with missing information were excluded from analyses. The remaining 675 rare plant records were used for analysis.

Variables used for various analyses are outlined in Appendix C. Unless otherwise mentioned below, variables used for analysis are the same as those collected in the field (see definitions in Table 5). Categorical qualitative data were transformed to dummy variables in order to calculate summary statistics and use the data in other analyses as described in subsequent sections below.

Summary Statistics

Summary statistics including means ($\pm$ standard error) and modes for all population-based parameters and disturbance or habitat-based parameters were computed to provide an overall assessment of all surveyed management zones in the park.

To assess the distribution of specialized habitats in the park, frequency distributions or histograms were created using coefficient of conservatism (CoC) scores across the entire park and based on surveyed management zones.

Correlation Analyses

Spearman rank correlation analyses were performed on several pairs of continuous and categorical variables to allow further assessments of positive or negative relationships between rare species population estimates and potentially correlated parameters. Population-based measures of rare plant species (i.e., population density, population size, and areal percent cover) were compared to five parameters representing measures of disturbance (i.e., percent deer browse, IERAT score, presence of erosion, human disturbance, and number of deer trails). Additionally, correlations were performed between rare plant species metrics and invasive species metrics to determine if species associations may have influenced the presence or abundance of rare plant species. These analyses were performed across all 675 rare plant records and as such, the significance level, α for the correlations was set at 0.001.

Multivariate Analyses

To characterize the plant community composition in terms of its park-wide distribution and to identify factors influencing rare species assemblages, a series of multivariate statistical techniques, including factor analysis and ordination analysis, were used. Factor analysis was used to assess multicollinearity and remove redundancy in the environmental data comprising habitat, landscape,

and disturbance-based variables. Ordination analysis was conducted using a presence-absence matrix of rare species and environmental covariates simultaneously in order to determine how species distribution patterns varied along environmental gradients.

All environmental variables on a continuous scale were $\log_{10}(Y+1)$ transformed to improve homogeneity of variances and normality of data. Variables that represented percentages were converted to proportions and arcsine squareroot transformed. Factor analysis was conducted on a correlation matrix of 35 environmental variables to identify redundancy in the data. Variables with the highest factor loadings within each factor were chosen for further analyses. In the case where two variables were grouped into one factor but were not intuitively related to each other, both variables were selected for further analyses.

Ordination Analysis

Rare plant community assemblages across all surveyed areas of the park were examined using canonical correspondence analysis to examine species patterns and environmental variation in low dimensional space. Canonical Correspondence Analysis (CCA) is a type of multivariate ordination analysis that allows the simultaneous inclusion of biotic and abiotic data in the model to elucidate patterns of response to environmental or habitat variation.

The rare plant data, comprising 98 species, were transformed into a presence-absence matrix based on all 675 records. Species with fewer than 4 records or occurrences were excluded from further analyses to dampen the effects of potential overweighting of infrequently observed species (Gauch and Gauch, 1982). The records associated with species that were excluded from the final species matrix were therefore also excluded from further analyses resulting in a total of 600 records for the ordination analysis. The environmental matrix consisted of the 20 continuous and categorical variables that were selected from the results of the factor analysis.

A preliminary detrended correspondence analysis was performed to determine gradient lengths and the applicability of the CCA based on expected unimodal species responses.

Density Map

The Point Density tool, part of ArcMap's spatial analyst toolset, was used to create a heat map for rare plant occurrence and rare plant population size. Population size is a mixed data value (stems and/or clumps), rather than one source type, which can over-represent density. The Point Density tool utilizes a user-defined neighborhood to calculate the density of point features around each output raster cell. The sum value of points within a neighborhood is divided by its size to get each cell's density value. A cell size of 50m and a neighborhood radius of 200m was used to create a more generalized output raster. An area unit scale factor of kilometers was used to calculate density per square kilometer due to very small return values when map units (meters) were used as the output. The symbology classification method Natural Breaks (Jenks) was used and is divided into eight classes.

Rare plant occurrences were interpolated using ArcMap's Inverse Distance Weighted (IDW) raster interpolation tool. IDW defines a value for unsampled locations using a linear, inversely weighted

distance average of surrounding sample points (as locations get farther from the sampled point, the predicted number of rare plant occurrences decreases). We used a variable search radius of 20 points, where the radius distance varies for each interpolated cell, with a maximum search distance of 200m to avoid using distant points that have little to no spatial correlation. We used the default power of 2 for this analysis.

Ideally, locations would have been more densely sampled to interpolate a smoother raster surface; since the rare plant locations were sparse and unevenly distributed, the results may not sufficiently represent the distribution of rare plant areas. Other techniques could be used in the future to define rare plant areas, such as Moving Window Kriging or Empirical Bayesian Kriging. We did not have access to the geostatistical analyst extension for ArcMap, which could be used to perform further interpolation analysis with multiple variables in the future.

Results and Discussion

A total of 98 species and 675 rare plant locations were inventoried during the survey (Appendix D). Additional details are broken down by geographic area in the following sections. For a discussion of individual rare plant species, see Appendix E.

Level of Effort

The field survey effort took place from April 7, 2021, to September 30, 2021. Eight EnviroScience botanists spent approximately 2,900 hours completing transects and meander surveys and identifying plants. A summary of field effort by month is contained in Table 6.

Table 6. Summary of 2021 Field Effort.

Field Effort	April	May	June	July	August	September	Total
Transects Surveyed	110	254	306	353	494	257	1774
Transects with Rare Plant Records	7	33	54	66	52	17	229
% of Transects with Rare Plants	6%	14%	17%	20%	28%	15%	13%
Hours	260	420	467	572	667	607	2992
Hours/Transect	2.37	1.65	1.52	1.62	1.35	2.36	1.69

Distribution of Rare Plants Throughout Park

The distribution of rare plant species throughout the park is discussed individually by area below. Population size, percent cover, and the five environmental disturbance metrics collected (human disturbance, percent deer browse, deer trails, IERAT score, and erosion) are summarized in Table 5. It is important to note that the disturbance metrics collected as categorical data were converted to numerical data for purposes of statistical analysis. In most cases, the major disturbances at rare plant locations were deer and earthworms. Human disturbance was negligible in most rare plant locations. High use areas such as the Ledges had few rare plant records in 2021 despite having more records historically. However, any apparent relationship between visitor use and rare plant population is purely anecdotal. Determining a statistical relationship between visitor use and rare plant populations would require the collection of covariate/disturbance data at rare plant absences, which was not done for this project.

Adams Run Natural Zone

The Adams Run Natural Zone occupies 1,329.0 ac. in the park (Figure 1). The NPS Vegetation Class data shows 22 vegetation classes within the zone. Major NPS mapped vegetation communities include Successional Mixed Hardwood Forest, Dry-mesic Oak Forest, and Developed Area – Low Intensity, which comprise 60% of this zone. Ninety-nine historic rare plant occurrences are known within its boundaries. In 2021, 14 rare plant records comprising eight species were found within its

boundaries. For these rare plant records, mean population size was 29.36 ± 11.83 , mean population density was 2.14 ± 0.66 individuals/m², and mean percent areal cover was 2.21 ± 0.74 .

Invasive species did not appear to be a major factor at these locations: the total number of species observed at the rare plant locations was four, with a mean percent cover of 2.93 ± 1.41 . Mean human disturbance at the records was 0.6 ± 0.2 (Some). Mean percent deer browse was 17.9 ± 7.1 (Some). Mean number of deer trails was 0.6 ± 0.1 (Some). Mean IERAT Score was 2.4 ± 0.2 . Mean erosion score was 0.2 ± 0.2 (None).

A-P North Sensitive Resources Zone

The A-P North Sensitive Resources Zone occupies 1,437.1 ac. in the park (Figure 1). The NPS Vegetation Class data shows 19 vegetation classes within the zone. Major NPS mapped vegetation communities within the zone include Dry-mesic Oak Forest, Successional Mixed Hardwood Forest, and Beech-Maple Glaciated Forest, which comprise 73% of this zone. Fourteen historic rare plant occurrences are known within its boundaries. In 2021, 142 rare plant records comprising 36 species were found within its boundaries. For these rare plant records, mean population size was 31.37 ± 7.21 , mean population density was 3.33 ± 0.82 individuals/m², and mean percent areal cover was 4.83 ± 1.23 .

Invasive species did not appear to be a major factor at these locations, as the mean percent cover of invasive species at rare plant locations was 3.82 ± 0.69 . Mean human disturbance at the records was 0.4 ± 0.1 (None). Mean percent deer browse was 24.8 ± 1.2 (Some). Mean number of deer trails was 0.7 ± 0.1 (Some). Mean IERAT Score was 3.4 ± 0.1 . Mean erosion score was 0.5 ± 0.1 (None).

Bath Road to Peninsula River Corridor Zone

The Bath Road to Peninsula River Corridor Zone occupies 1,463.2 ac. in the park (Figure 1). The NPS Vegetation Class data shows 32 vegetation classes within the zone. Major vegetation communities within the zone include Cottonwood-Sycamore Floodplain Forest, Developed Area-Low Intensity, and Cultivated Herbaceous Row Crop, which comprise 58% of this zone. Ten historic rare plant occurrences are known within its boundaries. In 2021, 30 rare plant records comprising eight species were found within its boundaries. For these rare plant records, mean population size was 187.07 ± 166.03 , mean population density was 3.36 ± 1.17 individuals/m², and mean percent areal cover was 10.04 ± 0.75 .

The mean percent cover of invasive species at rare plant locations was 34.72 ± 3.81 . Mean human disturbance at the records was 0.5 ± 0.2 (Some). Mean percent deer browse was 20.0 ± 2.8 (Some). Mean number of deer trails was 0.7 ± 0.1 (Some). Mean IERAT Score was 3.4 ± 0.2 . Mean erosion score was 0.1 ± 0.1 (None).

Blossom Woods Natural Zone

The Blossom Woods Natural Zone occupies 2,896.0 ac. in the park (Figure 1). The NPS Vegetation Class data shows 23 vegetation classes within the zone. Major vegetation communities within the zone include Dry-mesic Oak Forest, Successional Mixed Hardwood Forest, and Beech-Maple Glaciated Forest, which comprise 81% of this zone. Thirty-one historic rare plant occurrences are known within its boundaries. In 2021, 105 rare plant records comprising 35 species were found

within its boundaries. For these rare plant records, mean population size was 48.95 ± 15.32 , mean population density was 4.69 ± 1.39 individuals/m², and mean percent areal cover was 3.16 ± 0.75 .

Invasive species did not appear to be a major factor at these locations, as the mean percent cover of invasive species at rare plant locations was 6.98 ± 1.12 . Mean human disturbance at the records was 0.3 ± 0.1 (None). Mean percent deer browse was 20.2 ± 1.3 (Some). Mean number of deer trails was 0.5 ± 0.1 (Some). Mean IERAT Score was 3.2 ± 0.1 . Mean erosion score was 0.3 ± 0.1 (None).

Blue Hen Falls Natural Zone

The Blue Hen Falls Natural Zone occupies 136.7 ac. in the park (Figure 1). The NPS Vegetation Class data shows 9 vegetation classes within the zone. Major vegetation communities within the zone include Dry-mesic Oak Forest, Beech-Maple Glaciated Forest, and Successional Mixed Hardwood Forest, which comprise 89% of this zone. Eleven historic rare plant occurrences are known within its boundaries. In 2021, five rare plant records comprising four species were found within its boundaries. For these rare plant records, mean population size was 11.20 ± 3.79 , mean population density was 2.60 ± 0.68 individuals/m², and mean percent areal cover was 1.62 ± 0.86 .

Invasive species did not appear to be a major factor at these locations, as the mean percent cover of invasive species at rare plant locations was 8.42 ± 2.84 . Mean human disturbance at the records was 0.8 ± 0.4 (Some). Mean percent deer browse was 25 ± 0.0 (Some). Mean number of deer trails was 0.2 ± 0.2 (None). Mean IERAT Score was 3.6 ± 0.2 . Mean erosion score was 0.2 ± 0.2 (None).

Boston Mills Historic District Zone

The Boston Mills Historic District Zone occupies 31.5 ac. in the park (Figure 1). The NPS Vegetation Class data shows 8 vegetation classes within the zone. Major vegetation communities within the zone include Developed Area-Low Intensity, Successional Mixed Hardwood Forest, and Developed Area-Medium Intensity, which comprise 70% of the area. No historic rare plant occurrences are known within its boundaries, and no rare plant records were found within its boundaries in 2021.

Botzum Natural Zone

The Botzum Natural Zone occupies 789.9 ac. in the park (Figure 1). The NPS Vegetation Class data shows 21 vegetation classes within the zone. Major vegetation communities within the zone include Successional Mixed Hardwood Forest, Developed Area-Low Intensity, and Dry-mesic Oak Forest, which comprise 72% of this zone. Twenty-eight historic rare plant occurrences are known within its boundaries. In 2021, two rare plant records comprising two species were found within its boundaries. The summary statistics should be interpreted with caution due to the low number of records. For these rare plant records, mean population size was 261 ± 239 , mean population density was 9.20 ± 4.80 individuals/m², and mean percent areal cover was 50.0 ± 35.0 .

Invasive species did not appear to be a major factor at these locations, as the mean percent cover of invasive species at rare plant locations was 13.50 ± 1.50 . Mean human disturbance at the records was 0 ± 0 (None). Mean percent deer browse was 37.5 ± 37.5 (Some). Mean number of deer trails was 1 ± 0 (Some). Mean IERAT Score was 3.0 ± 2 . Mean erosion score was 0 ± 0 (None).

Canal Cultural High Value Experience Zone

The Canal Cultural High Value Experience Zone occupies 302.1 ac. in the park (Figure 1). The NPS Vegetation Class data shows 22 vegetation classes within the zone. Major vegetation communities within the zone include Successional Mixed Hardwood Forest, Developed Area-Low Intensity, and Cottonwood-Sycamore Floodplain Forest, which comprises 45% of this zone. Three historic rare plant occurrences are known within its boundaries. In 2021, two rare plant records comprising two species were found within its boundaries. The summary statistics should be interpreted with caution due to the low number of records. For these rare plant records, mean population size was 40.5 ± 39.5 , mean population density was 2.50 ± 1.50 individuals/m², and mean percent areal cover was 30.0 ± 20.0 .

Invasive species were a major factor at some of these locations, as the mean percent cover of invasive species at rare plant locations was 52.0 ± 51.0 . Mean human disturbance at the records was 1.5 ± 0.5 (Extensive). Mean percent deer browse was 50 ± 25 (Extensive). Mean number of deer trails was 1 ± 0 (Some). Mean IERAT Score was 3 ± 0 . Mean erosion score was 0.5 ± 0.5 (Some).

Coliseum Natural Zone

The Coliseum Natural Zone occupies 323.9 ac. in the park (Figure 1). The NPS Vegetation Class data shows 12 vegetation classes within the zone. Major vegetation communities within the zone include Successional Mixed Hardwood Forest, Dry-mesic Oak Forest, Successional Dry-Mesic Herbaceous Field, and comprise 81% of this zone. One historic rare plant occurrence is known within its boundaries. No rare plants were found in this management zone in 2021.

Columbia Sensitive Resources Zone

The Columbia Sensitive Resources Zone occupies 715.6 ac. in the park (Figure 1). The NPS Vegetation Class data shows 14 vegetation classes within the zone. Major vegetation communities within the zone include Successional Mixed Hardwood Forest, Dry-mesic Oak Forest, and Beech-Maple Glaciated Forest, which comprise 81% of this zone. Twenty-seven historic rare plant occurrences are known within its boundaries. In 2021, 37 rare plant records comprising 16 species were found within its boundaries. For these rare plant records, mean population size was 21.62 ± 14.43 , mean population density was 4.42 ± 1.18 individuals/m², and mean percent areal cover was 3.95 ± 1.66 .

Invasive species did not appear to be a major factor at these locations, as the mean percent cover of invasive species at rare plant locations was 5.36 ± 2.11 . Mean human disturbance at the records was 0.7 ± 0.1 (Some). Mean percent deer browse was 22.3 ± 1.3 (Some). Mean number of deer trails was 0.6 ± 0.1 (Some). Mean IERAT Score was 3.4 ± 0.2 . Mean erosion score was 0.2 ± 0.1 (None).

Everett Cultural High Value Experience Zone

The Everett Cultural High Value Experience Zone occupies 1,580.0 ac. in the park (Figure 1). The NPS Vegetation Class data shows 23 vegetation classes within the zone. Major vegetation communities within the zone include Successional Mixed Hardwood Forest, Dry-mesic Oak Forest, and Beech-Maple Glaciated Forest, which comprise 67% of this zone. Fifteen historic rare plant occurrences are known within its boundaries. In 2021, 10 rare plant records comprising seven species

were found within its boundaries. For these rare plant records, mean population size was 4.80 ± 1.47 , mean population density was 3.25 ± 0.7 individuals/m², and mean percent areal cover was 2.51 ± 0.68 .

Invasive species did not appear to be a major factor at these locations, as the mean percent cover of invasive species at rare plant locations was 6.90 ± 2.98 . Mean human disturbance at the records was 0.3 ± 0.2 (None). Mean percent deer browse was 15.0 ± 4.1 (Some). Mean number of deer trails was 0.5 ± 0.2 (Some). Mean IERAT Score was 2.9 ± 0.4 . Mean erosion score was 0.5 ± 0.2 (Some).

Furnace Run South - Oak Hill Natural Zone

The Furnace Run South - Oak Hill Natural Zone occupies 4,205.3 ac. in the park (Figure 1). The NPS Vegetation Class data shows 29 vegetation classes within the zone. Major vegetation communities within the zone include Successional Mixed Hardwood Forest, Dry-mesic Oak Forest, and Beech-Maple Glaciated Forest, which comprise 69% of this zone. Seventy-one historic rare plant occurrences are known within its boundaries. In 2021, 23 rare plant records comprising 13 species were found within its boundaries. For these rare plant records, mean population size was 24.00 ± 17.25 , mean population density was 2.32 ± 0.48 individuals/m², and mean percent areal cover was 7.67 ± 3.02 .

The mean percent cover of invasive species at rare plant locations was 11.53 ± 3.58 . Mean human disturbance at the records was 0.8 ± 0.2 (Some). Mean percent deer browse was 27.2 ± 2.2 (Some). Mean number of deer trails was 1.0 ± 0.1 (Some). Mean IERAT Score was 3.1 ± 0.2 . Mean erosion score was 0.4 ± 0.1 (None).

Interstate Natural Zone

The Interstate Natural Zone occupies 142.3 ac. in the park (Figure 1). The NPS Vegetation Class data shows 11 vegetation classes within the zone. Major vegetation communities within the zone include Successional Mixed Hardwood Forest, Dry-mesic Oak Forest, and Beech-Maple Glaciated Forest, which comprise 78% of this zone. One historic rare plant occurrence is known within its boundaries. In 2021, two rare plant records of a single species were found within its boundaries. The summary statistics should be interpreted with caution due to the low number of records. For these rare plant records, mean population size was 6.00 ± 4.00 , mean population density was 3.50 ± 1.50 individuals/m², and mean percent areal cover was 10.00 ± 5.00 .

Invasive species did not appear to be a major factor at these locations, as the mean percent cover of invasive species at rare plant locations was 4.00 ± 3.00 . Mean human disturbance at the records was 0.5 ± 0.5 (Some). Mean percent deer browse was 25.0 ± 0 (Some). Mean number of deer trails was 1.0 ± 0.0 (Some). Mean IERAT Score was 3.5 ± 0.5 . Mean erosion score was 1.0 ± 1.0 (Some).

Areas Outside Management Zones

Some portions of the survey were conducted in areas outside the management zones. These areas occupy 5,353.3 ac. in the park and include portions of Furnace Run Metro Park (Summit Metro Parks) and Brecksville and Bedford Reservations (Cleveland Metroparks) (Figure 1). One hundred ninety historic rare plant occurrences are known within its boundaries. In 2021, 34 rare plant records comprising 21 species were found within its boundaries. For these rare plant records, mean

population size was 36.59 ± 14.50 , mean population density was 5.55 ± 1.84 individuals/m², and mean percent areal cover was 10.09 ± 4.01 .

Invasive species did not appear to be a major factor at these locations, as the mean percent cover of invasive species at rare plant locations was 7.76 ± 2.58 . Mean human disturbance at the records was 0.7 ± 0.1 (Some). Mean percent deer browse was 19.8 ± 3.6 (Some). Mean number of deer trails was 0.6 ± 0.1 (Some). Mean IERAT Score was 3.1 ± 0.3 . Mean erosion score was 0.4 ± 0.1 (None).

Northern Natural Zone

The Northern Natural Zone occupies 1,328.6 ac. in the park (Figure 1). The NPS Vegetation Class data shows 30 vegetation classes within the zone. Major vegetation communities within the zone include Successional Mixed Hardwood Forest, Dry-mesic Oak Forest, and Beech-Maple Glaciated Forest, which comprise 54% of this zone. No historic rare plant occurrences are known within its boundaries. In 2021, 12 rare plant records comprising eight species were found within its boundaries. For these rare plant records, mean population size was 10.25 ± 3.98 , mean population density was 3.72 ± 1.99 individuals/m², and mean percent areal cover was 6.67 ± 4.02 .

The mean percent cover of invasive species at rare plant locations was 11.42 ± 2.26 . Mean human disturbance at the records was 1.3 ± 0.2 (Some). Mean percent deer browse was 33.3 ± 5.6 (Some). Mean number of deer trails was 0.8 ± 0.2 (Some). Mean IERAT Score was 3.0 ± 0.4 . Mean erosion score was 0.1 ± 0.1 (None).

Old Carriage Natural Zone

The Old Carriage Natural Zone occupies 701.2 ac. in the park (Figure 1). The NPS Vegetation Class data shows 15 vegetation classes within the zone. Major vegetation communities within the zone include Dry-mesic Oak Forest, Successional Mixed Hardwood Forest, and Beech-Maple Glaciated Forest, which comprise 86% of this zone. Twelve historic rare plant occurrences are known within its boundaries. In 2021, 11 rare plant records comprising six species were found within its boundaries. For these rare plant records, mean population size was 103.00 ± 53.70 , mean population density was 8.28 ± 3.55 individuals/m², and mean percent areal cover was 11.77 ± 4.87 .

The mean percent cover of invasive species at rare plant locations was 7.74 ± 2.43 . Mean human disturbance at the records was 0.7 ± 0.2 (Some). Mean percent deer browse was 25.0 ± 5.0 (Some). Mean number of deer trails was 1.1 ± 0.2 (Some). Mean IERAT Score was 3.0 ± 0.4 . Mean erosion score was 0.6 ± 0.2 (Some).

Peninsula High Value Recreation Zone

The Peninsula High Value Recreation Zone occupies 155.7 ac. in the park (Figure 1). The NPS Vegetation Class data shows 15 vegetation classes within the zone. Major vegetation communities within the zone include Cottonwood-Sycamore Floodplain Forest, Dry-mesic Oak Forest, and Successional Mixed Hardwood Forest, which comprise 63% of this zone. Three historic rare plant occurrences are known within its boundaries. In 2021, no rare plants were found within its boundaries.

Peninsula to Boston Mills River Corridor Zone

The Peninsula to Boston Mills River Corridor Zone occupies 196.9 ac. in the park (Figure 1). The NPS Vegetation Class data shows 17 vegetation classes within the zone. Major vegetation communities within the zone include Cottonwood-Sycamore Floodplain Forest, Successional Central Wet-Mesic Herbaceous Field, and Stream and River, which comprise 54% of this zone. Seven historic rare plant occurrences are known within its boundaries. In 2021, one rare plant record was found within its boundaries. This plant record had a population of 10, density of 10 individuals/m², and occupied 20 percent areal cover.

Invasive species has a mean areal cover of 3 percent. Human disturbance at the record was 1 (Some) and deer browse was 25 (Some). Deer trails were ranked as Some (1). The IERAT Score was 1, and the erosion score was 0 (None).

Pinery Narrows/Twin Sisters Sensitive Resource Zone

The Pinery Narrows/Twin Sisters Sensitive Resource Zone occupies 348.9 ac. in the park (Figure 1). The NPS Vegetation Class data shows 12 vegetation classes within the zone. Major vegetation communities within the zone include Dry-mesic Oak Forest, Successional Mixed Hardwood Forest, Beech-Maple Glaciated Forest, which comprise 77% of this zone. Nineteen historic rare plant occurrences are known within its boundaries. In 2021, five rare plant records comprising five species were found within its boundaries. For these rare plant records, mean population size was 8.83 ± 5.38 , mean population density was 2.40 ± 0.98 individuals/m², and mean percent areal cover was 2.00 ± 1.00 .

The mean percent cover of invasive species at rare plant locations was 5.00 ± 1.58 . Mean human disturbance at the records was 0.2 ± 0.2 (None). Mean percent deer browse was 25.0 ± 13.7 (Some). Mean number of deer trails was 0.8 ± 0.4 (Some). Mean IERAT Score was 2.2 ± 0.4 . Mean erosion score was 0.4 ± 0.4 (None).

Snowville Woods Natural Zone

The Snowville Woods Natural Zone occupies 2,138.2 ac. in the park (Figure 1). The NPS Vegetation Class data shows 24 vegetation classes within the zone. Major vegetation communities within the zone include Successional Mixed Hardwood Forest, Dry-mesic Oak Forest, and Beech-Maple Glaciated Forest, which comprise 77% of this zone. Forty-two historic rare plant occurrences are known within its boundaries. In 2021, 14 rare plant records comprising seven species were found within its boundaries. For these rare plant records, mean population size was 66.79 ± 36.41 , mean population density was 4.56 ± 2.08 individuals/m², and mean percent areal cover was 4.57 ± 1.64 .

The mean percent cover of invasive species at rare plant locations was 16.11 ± 6.32 . Mean human disturbance at the records was 0.9 ± 0.2 (Some). Mean percent deer browse was 16.1 ± 3.3 (Some). Mean number of deer trails was 0.6 ± 0.1 (Some). Mean IERAT Score was 3.3 ± 0.3 . Mean erosion score was 0.2 ± 0.1 (None).

Stanford Run /Hines Hill High Value Experience Zone

The Stanford Run /Hines Hill High Value Experience Zone occupies 2,173.6 ac. in the park (Figure 1). The NPS Vegetation Class data shows 25 vegetation classes within the zone. Major

vegetation communities within the zone include Dry-mesic Oak Forest, Successional Mixed Hardwood Forest, and Beech-Maple Glaciated Forest, which comprise 64% of this zone. Forty-two historic rare plant occurrences are known within its boundaries. In 2021, 65 rare plant records comprising 24 species were found within its boundaries. For these rare plant records, mean population size was 44.14 ± 9.83 , mean population density was 4.39 ± 1.01 individuals/m², and mean percent areal cover was 7.06 ± 1.50 .

The mean percent cover of invasive species at rare plant locations was 15.33 ± 2 . Mean human disturbance at the records was 0.5 ± 0.1 (Some). Mean percent deer browse was 21.2 ± 2.9 (Some). Mean number of deer trails was 0.5 ± 0.1 (Some). Mean IERAT Score was 3.4 ± 0.2 . Mean erosion score was 0.2 ± 0.1 (None).

Station Road to Boston Mills River Corridor Zone

The Station Road to Boston Mills River Corridor Zone occupies 842.1 ac. in the park (Figure 1). The NPS Vegetation Class data shows 27 vegetation classes within the zone. Major vegetation communities within the zone include Cottonwood-Sycamore Floodplain Forest, Reed Canary Grass Eastern Marsh, and Stream and River, which comprise 65% of this zone. Twenty-two historic rare plant occurrences are known within its boundaries. In 2021, 37 rare plant records comprising eight species were found within its boundaries. For these rare plant records, mean population size was 35.11 ± 8.1 , mean population density was 3.69 ± 0.79 individuals/m², and mean percent areal cover was 6.65 ± 2.04 .

Invasive species appeared to be a major factor at these locations, as the mean percent cover of invasive species at rare plant locations was 23.99 ± 2.99 . Mean human disturbance at the records was 0.7 ± 0.1 (Some). Mean percent deer browse was 23.6 ± 3.9 (Some). Mean number of deer trails was 0.7 ± 0.1 (Some). Mean IERAT Score was 3.0 ± 0.2 . Mean erosion score was 0.1 ± 0.04 (None).

Station Road to Rockside River Corridor Zone

The Station Road to Rockside River Corridor Zone occupies 740.9 ac. in the park (Figure 1). The NPS Vegetation Class data shows 29 vegetation classes within the zone. Major vegetation communities within the zone include Cottonwood-Sycamore Floodplain Forest, Stream and River, and Reed Canary Grass Eastern Marsh, which comprise 62% of this zone. One historic rare plant occurrence is known within its boundaries. In 2021, seven rare plant records comprising three species were found within its boundaries. For these rare plant records, mean population size was 20.57 ± 13.6 , mean population density was 2.64 ± 0.88 individuals/m², and mean percent areal cover was 9.00 ± 3.57 .

Invasive species appeared to be a major factor at these locations, as the mean percent cover of invasive species at rare plant locations was 19.64 ± 8.17 . Mean human disturbance at the records was 0.7 ± 0.4 (Some). Mean percent deer browse was 7.1 ± 4.6 (Some). Mean number of deer trails was 0.3 ± 0.2 (Some). Mean IERAT Score was 2.0 ± 0.4 . Mean erosion score was 0.3 ± 0.2 (None).

Terra Vista Natural Zone

The Terra Vista Natural Zone occupies 264.0 ac. in the park (Figure 1). The NPS Vegetation Class data shows 15 vegetation classes within the zone. Major vegetation communities within the zone

include Successional Mixed Hardwood Forest, Successional Autumn Olive-Hawthorn-Multiflora Rose Shrubland, and Successional Cottonwood Forest, which comprise 68% of this zone. No historic rare plant occurrences are known within its boundaries. In 2021, two rare plant records from a single species were found within its boundaries. The summary statistics should be interpreted with caution due to the low number of records. For these rare plant records, mean population size was 11.50 ± 1.50 , mean population density was 0.48 ± 0.33 individuals/m², and mean percent areal cover was 0.75 ± 0.25 .

The mean percent cover of invasive species at rare plant locations was 6.00 ± 2.5 . Mean human disturbance at the records was 1.5 ± 0.5 (Extensive). Mean percent deer browse was 25 ± 0.0 (Some). Mean number of deer trails was 0 ± 0.0 (None). Mean IERAT Score was 4.0 ± 0.0 . Mean erosion score was 0 ± 0.0 (None).

Twin Sisters-Mudcatcher Sensitive Resource Zone

The Twin Sisters-Mudcatcher Sensitive Resource Zone occupies 232.8 ac. in the park (Figure 1). The NPS Vegetation Class data shows 12 vegetation classes within the zone. Major vegetation communities within the zone include Successional Mixed Hardwood Forest, Beech-Maple Glaciated Forest, and Dry-mesic Oak Forest, which comprise 77% of this zone. No historic rare plant occurrences are known within its boundaries. In 2021, four rare plant records comprising three species were found within its boundaries. For these rare plant records, mean population size was 4.25 ± 1.97 , mean population density was 2.75 ± 1.75 individuals/m², and mean percent areal cover was 2.50 ± 1.19 .

The mean percent cover of invasive species at rare plant locations was 7.50 ± 1.44 . Mean human disturbance at the records was 0 ± 0.0 (None). Mean percent deer browse was 37.5 ± 21.6 (Some). Mean number of deer trails was 1 ± 0.0 (Some). Mean IERAT Score was 1.5 ± 0.3 . Mean erosion score was 0.5 ± 0.3 (Some).

Virginia Kendall High Value Experience Zone

The Virginia Kendall High Value Experience Zone occupies 2,889.4 ac. in the park (Figure 1). The NPS Vegetation Class data shows 26 vegetation classes within the zone. Major vegetation communities within the zone include Dry-mesic Oak Forest, Successional Mixed Hardwood Forest, and Beech-Maple Glaciated Forest, which comprise 67% of this zone. Ninety historic rare plant occurrences are known within its boundaries. In 2021, 111 rare plant records comprising 33 species were found within its boundaries. For these rare plant records, mean population size was 28.09 ± 9.65 , mean population density was 2.67 ± 0.46 individuals/m², and mean percent areal cover was 9.51 ± 1.77 .

The mean percent cover of invasive species at rare plant locations was 11.23 ± 1.75 . Mean human disturbance at the records was 0.7 ± 0.1 (Some). Mean percent deer browse was 22.5 ± 1.4 (Some). Mean number of deer trails was 0.3 ± 0.04 (None). Mean IERAT Score was 2.8 ± 0.1 . Mean erosion score was 0.2 ± 0.04 (None).

Suggested Additions to the list

In addition to the species on the list, four additional species were documented during the survey: *Morella pensylvanica*, *Platanthera lacera*, *Spiranthes cernua*, and *Tipularia discolor*. *Morella pensylvanica* is state endangered, but the other species are not on the Rare Native Ohio Plants 2020–21 Status List. While these species are widely distributed in the United States, most of them were only found in one location in the park. We suggest that they be added to the rare plant target species list.

Historic Rare Species Not Detected During Survey

Fifty-four species were listed as historically occurring in the study area but were not identified during the 2021 survey—see Appendix D. The major observed parkwide environmental factors of human use, deer, and earthworms may explain the lack of these species. Conversely, they may have been missed because most transects were only visited once and the species were not in bloom during the time when the transect was surveyed. Focused surveys could potentially document these species. Appendix E contains commentary on each rare plant species, including those not detected during the 2021 survey.

Results of Univariate and Multivariate Analyses

Coefficients of Conservatism

Across all surveyed management zones, the most frequently observed CoC score was 7, with 195 records, followed by a score of 5, with 128 records, and a score of 6 with 111 records, respectively (Figure 5).

A high CoC score indicates more conservative or specialized habitat requirements. Low CoC species are generalists and can be found in a variety of habitat types. Species with high CoC scores are more likely to be lost when habitats change. Species with low CoC scores are more likely to be able to adapt to habitat change. Clusters of records with high CoC indicate habitats that should be protected, because if they're degraded, rare species in those areas may be lost.

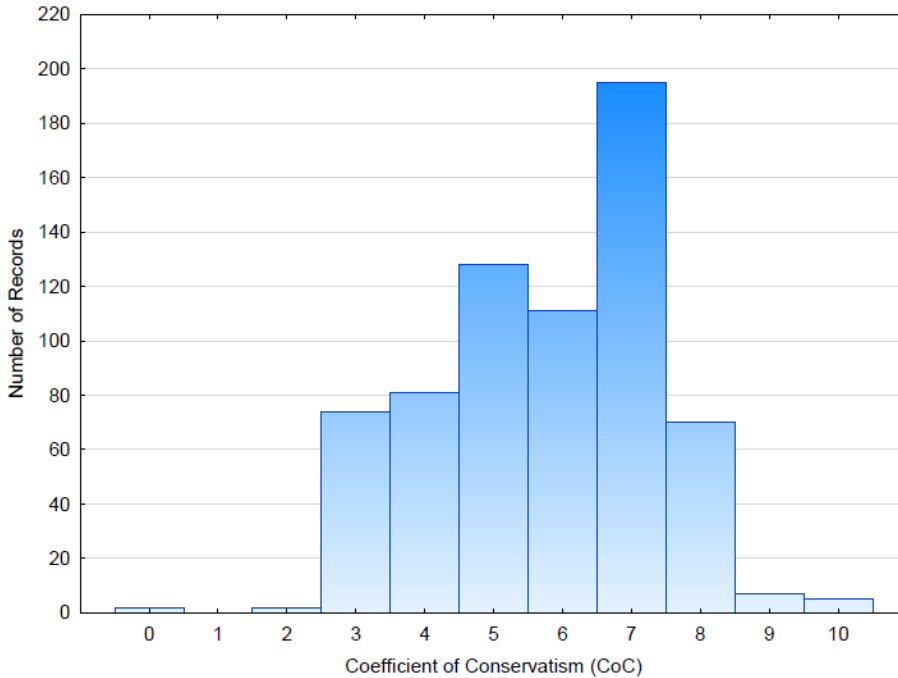


Figure 5. Frequency distribution of coefficient of conservatism (CoC) values for 675 rare plant records across all management zones in CUVA.

The highest CoC score of 10 was attributed to four records noted in the Virginia Kendall High Value Experience zone and one record in the Stanford Run/Hines Hill High Value Experience zone. These zones should receive a high level of protection. If development is planned in these areas, areas around rare plant records should be avoided. Additional, targeted surveys should be conducted before any development, to find any rare plant populations that may have been missed in this survey. Foot traffic and other human disturbances should be prevented in areas surrounding rare plant occurrences.

A bivariate frequency distribution plot allowed for a detailed assessment and comparison of CoC scores among each of the 23 surveyed management zones (Figure 6). The most frequently recorded CoC score of 7 was observed in 20 of the 23 management zones with most of the records observed in the Station Road to Boston Mills River Corridor zone followed by Virginia Kendall, Blossom Woods Natural and Bath Road to Peninsula River Corridor. These management zones therefore contain relatively higher number of rare plants with more specialized habitat requirements compared to the other management zones. Foot traffic and other human disturbances should be minimized in areas surrounding rare plant occurrences.

The highest number of records for any one particular score was observed in the A-P North Sensitive Resources zone with a CoC score of 5 represented by 52 records followed by a score of 8 represented by 38 records, respectively. While comparatively less specialized in habitat structure, the A-P North Sensitive Resources zone may also be regarded as a sensitive area that may warrant further investigation for targeted management.

Only two rare plant records, observed in the management zones, Station Road to Rockside River Corridor and NA outside management zone, were associated with a CoC score of 0.

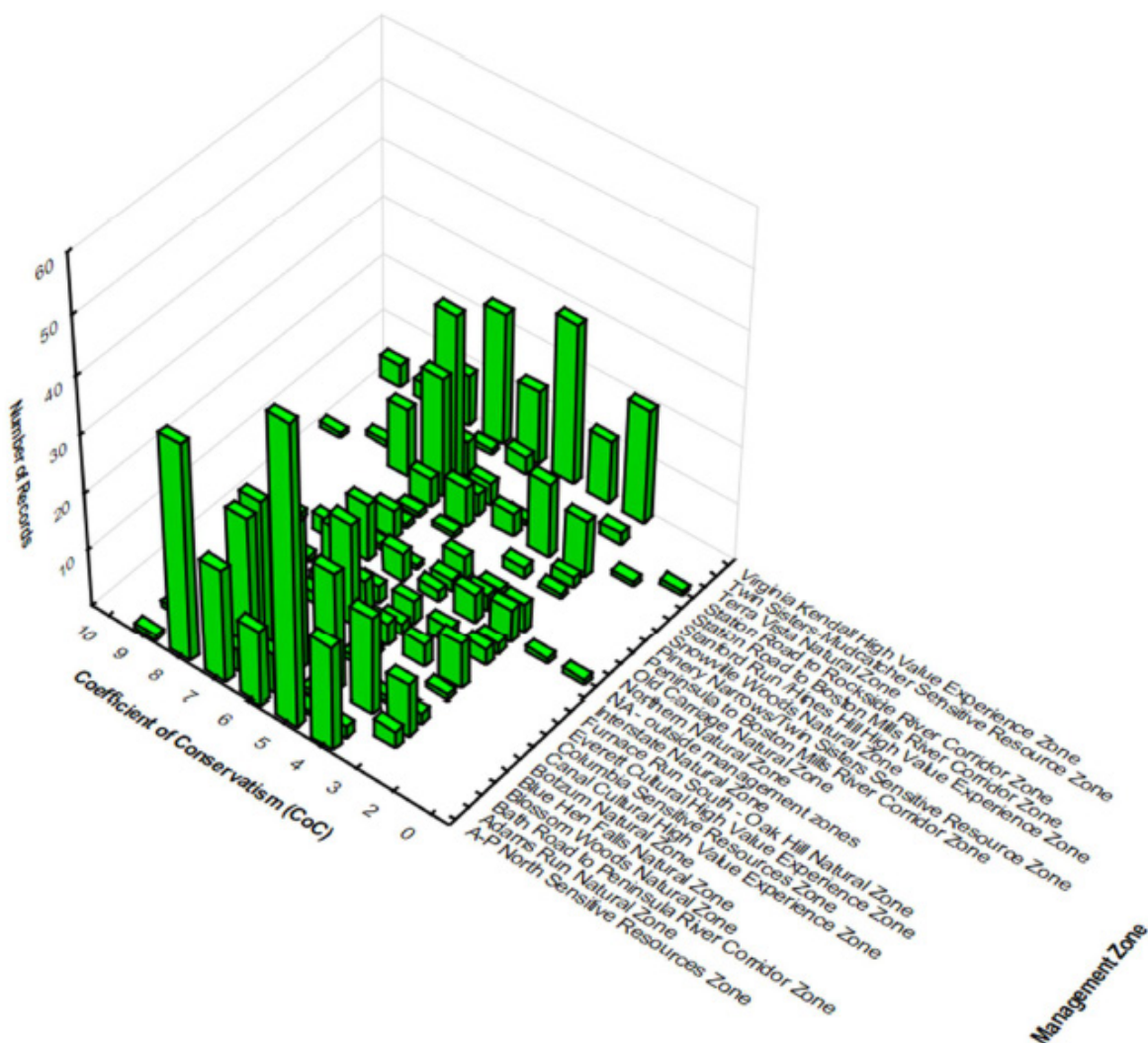


Figure 6. Bivariate frequency distribution of coefficient of conservatism (CoC) values for 23 management zones in CUVA.

Correlation Analyses

There was no significant correlation between coefficient of conservatism and total percent cover of invasive species at rare plant locations ($R = 0.046$, $p=0.231$, $N = 675$).

There was no significant correlation between total number of dominant species and total number of invasive species at rare plant locations ($R = 0.11$, $p = 0.0034$, $N = 675$).

There was a statistically significant albeit weak positive correlation between areal percent cover of rare species and total percent cover of invasive species at rare plant locations ($R= 0.29$, $p < 0.001$, $N = 675$), which was contrary to expectations. A scatterplot fitted with a locally weighted scatterplot

smoothing (LOWESS) trend line showed a very slight positive relationship between the two parameters (Figure 7). Invasive species are known to outcompete native species and can especially hinder the growth of rare species due to specialized habitat requirements of the latter. It is possible that the invasive species found to be in higher abundances occupied different microhabitats compared to the rare species recorded in the same locations. It is also possible that conditions that favor the growth of invasive plants at low concentrations are also favorable to the growth of rare plants, and that competition for resources at these low densities is not limiting to rare plant success. For these reasons, this weak positive correlation should not be used to draw the conclusion that increasing total percent cover of invasive plants would increase the abundance of rare species.

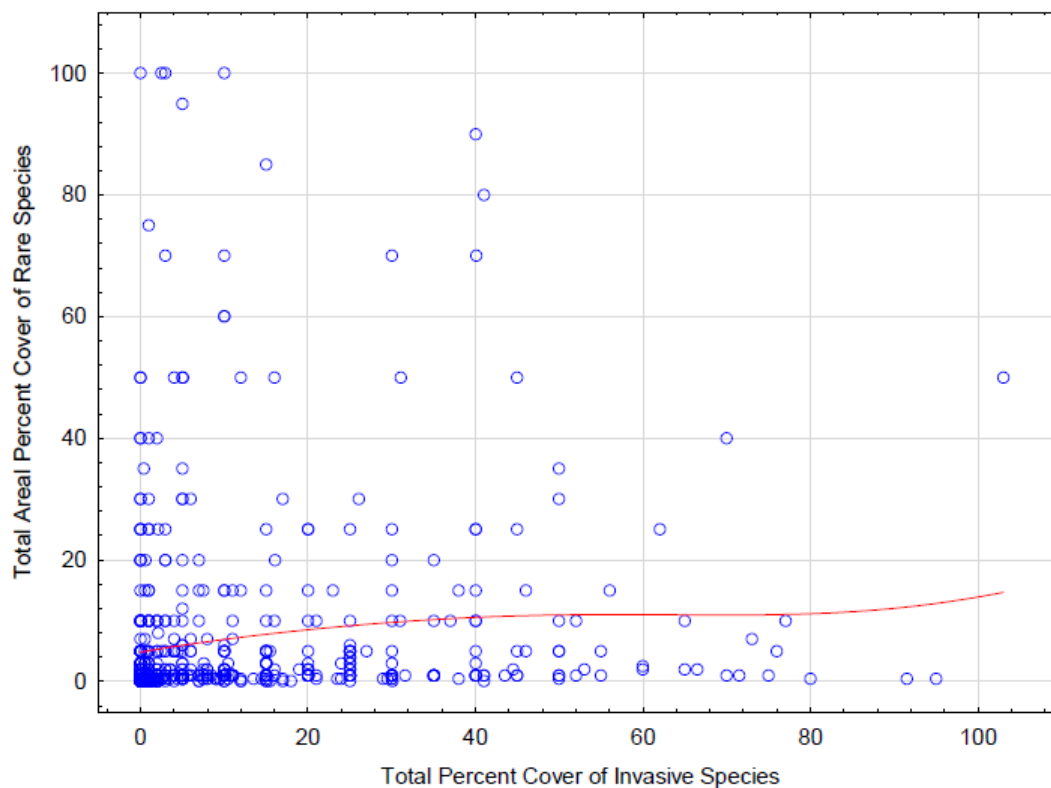


Figure 7. LOWESS plot showing relationship between the total areal percent cover of rare species and the total percent cover of invasive species.

Spearman rank correlation results between population-based measures of rare plant species (i.e., population density, population size and areal percent cover) and five parameters representing measures of disturbance (i.e., percent deer browse, IERAT score, presence of erosion, human disturbance and number of deer trails) showed no strong relationship likely due to the lack of any discernible variation among most of the categorical variables (Tables 7–9). The parameter, IERAT, was found to have a significant, albeit weak negative correlation with population density and areal percent cover of rare species suggesting that increased levels of earthworm infestation may be associated with fewer and less dense assemblages of rare plants (Tables 7 and 9). Percent deer

browse also showed a significant but weak correlation with areal percent cover of rare species indicating that habitats with higher rates of deer browsing may be associated with less rare plant coverage (Table 9).

Table 7. Spearman rank correlation results of population density of rare species and five parameters representing measures of disturbance, across all rare plant records in CUVA (N = 668).

Disturbance-Based Parameter	R	Adjusted p-value (Holm's method)
Percent Deer Browse	-0.08	0.389
IERAT Score	-0.16	0.0003
Presence of Erosion	0	1
Human Disturbance	0.02	1
Number of Deer Trails	-0.03	1

Table 8. Spearman rank correlation results of population size of rare species and five parameters representing measures of disturbance, across all rare plant records in CUVA (N = 669).

Disturbance-Based Parameter	R	Adjusted p-value (Holm's method)
Percent Deer Browse	-0.09	0.19
IERAT Score	-0.01	1
Presence of Erosion	-0.08	0.39
Human Disturbance	0.03	1
Number of Deer Trails	-0.02	1

Table 9. Spearman rank correlation results of areal percent cover of rare species and five parameters representing measures of disturbance, across all rare plant records in CUVA (N = 669).

Disturbance-Based Parameter	R	Adjusted p-value (Holm's method)
Percent Deer Browse	-0.17	0.0001
IERAT Score	-0.14	0.005
Presence of Erosion	0.002	1
Human Disturbance	0.09	0.13
Number of Deer Trails	0.09	0.149

Factor Analysis

Results for the factor analysis were obtained using varimax factor rotation. A total of 16 factors were extracted, explaining 74.3% of the total variance (Appendix F). Variables with the highest factor loadings within each factor were chosen for further analyses. In the case where two variables were grouped into one factor but were not intuitively related to each other, both variables were selected for further analyses. Twenty environmental variables were thus retained and used for subsequent ordination analyses (variables highlighted in red in Appendix F).

Canonical Correspondence Analysis (CCA)

A preliminary CCA iteration was performed to identify those variables that significantly contributed to explaining variation in the data. P-value adjustments were performed using the False Discovery Rate (FDR) method to avoid the contribution of Type I errors (Benjamini & Hochberg, 1995). Only those variables that showed a significant contribution to the model ($p < 0.05$, after adjustment) were selected for the final CCA model (Table 10).

Eighteen of the 20 explanatory variables selected for inclusion in the final model accounted for a total of 8.26% of the variation. CCA axes 1 and 2 explained 17.14% and 13.57% of the total variation in the data, respectively. Results of the final CCA are shown in Tables 11 and 12.

Table 10. Results of the first CCA iteration on rare plant species assemblages in CUVA showing the partitioned amount of variation explained by each variable in contributing to the model. All variables except for Shrub/Black Locust and Conifer were significant (after FDR-based p-value adjustments) and therefore selected for the final CCA model.

Variable	Explained Variation (%)	pseudo-F	P-value	Adjusted P-value (FDR)
Floodplain	1.25	7.5	0.001	0.0017
Invasive Species Richness	0.78	4.7	0.001	0.0017
Oak-Dominated	0.74	4.5	0.001	0.0017
No Disturbance	0.59	3.6	0.001	0.0017
No Erosion	0.55	3.4	0.001	0.0017
IERAT 1	0.49	3	0.001	0.0017
Well Drained Soil	0.4	2.5	0.001	0.0017
Wetland	0.37	2.3	0.01	0.0133
Developed	0.38	2.4	0.002	0.0028
No Deer Trails	0.37	2.3	0.001	0.0017
Distance to Outcrop	0.34	2.1	0.001	0.0017
Mixed Hardwood	0.33	2	0.001	0.0017
Distance to nearest Trail	0.33	2.1	0.001	0.0017
No Deer Browse	0.31	1.9	0.001	0.0017

Table 10 (continued). Results of the first CCA iteration on rare plant species assemblages in CUVA showing the partitioned amount of variation explained by each variable in contributing to the model. All variables except for Shrub/Black Locust and Conifer were significant (after FDR-based p-value adjustments) and therefore selected for the final CCA model.

Variable	Explained Variation (%)	pseudo-F	P-value	Adjusted P-value (FDR)
IERAT 2	0.26	1.6	0.012	0.0149
IERAT 3	0.27	1.7	0.002	0.0028
Dominant Species Richness	0.25	1.6	0.014	0.0155
Slope	0.24	1.5	0.013	0.0153
Shrub/Black Locust	0.21	1.3	0.107	0.1125
Conifer	0.2	1.2	0.272	0.2717

Table 11. Summary Statistics from the final model of the CCA on rare plant species assemblages in CUVA.

Statistic	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalues	0.5945	0.4711	0.3709	0.3381
Pseudo-canonical correlation	0.771	0.6863	0.609	0.5815
Explained fitted variation (cumulative)	17.14	30.71	41.4	51.15

Table 12. Environmental variables input in the final model of the CCA on rare plant species assemblages in CUVA showing the percent variation explained and the percent contribution along with the associated level of significance.

Variable	Explained Variation %	Contribution %	pseudo-F	P-value	Adjusted P-value
Floodplain	1.25	14.4	7.5	0.001	0.0013
Invasive Species	0.78	8.98	4.7	0.001	0.0017
Oak-Dominated	0.74	8.53	4.5	0.001	0.002
No Disturbance	0.59	6.83	3.6	0.001	0.0015
No Erosion	0.55	6.37	3.4	0.001	0.0014
IERAT 1	0.49	5.67	3	0.001	0.0015
Well Drained Soil	0.4	4.61	2.5	0.001	0.0015
Wetland	0.37	4.3	2.3	0.004	0.0057
Developed	0.38	4.44	2.4	0.002	0.0028

Table 12 (continued). Environmental variables input in the final model of the CCA on rare plant species assemblages in CUVA showing the percent variation explained and the percent contribution along with the associated level of significance.

Variable	Explained Variation %	Contribution %	pseudo-F	P-value	Adjusted P-value
No Deer Trails	0.37	4.23	2.3	0.001	0.0018
Outcrop	0.34	3.92	2.1	0.001	0.0017
Mixed Hardwood	0.33	3.77	2	0.001	0.0017
Trail	0.33	3.8	2.1	0.001	0.0017
No Deer Browse	0.31	3.57	1.9	0.001	0.0017
IERAT 2	0.26	2.99	1.6	0.006	0.008
IERAT 3	0.27	3.16	1.7	0.002	0.0028
Dominant Sp.	0.25	2.86	1.6	0.01	0.0118
Slope	0.24	2.81	1.5	0.008	0.0094

Results of the CCA biplot showed that the most important parameters associated with rare plant species assemblages in the park were floodplain vegetation, invasive species richness, oak dominated habitats and habitats with no presence of human disturbance (Figure 8). As expected, distance to the nearest trail was positively associated with the parameter, no disturbance indicating that as the distance to a trail increases, the likelihood of no human disturbance increases. Also not surprisingly, both these factors were negatively associated with the parameter, percentage of deer browse. The absence of erosion while not associated with any specific rare plant species was found to be negatively associated with slope. The latter variable showed strong positive association with the presence of several rare species including *Hydrocotyle americana* (American water-pennywort, HYAM), *Waldsteinia fragarioides* (Appalachian barren strawberry, WAFR), *Panax quinquefolius* (American ginseng, PAQU) and *Juniperus communis* (ground juniper, JUCO6). The most important variable, floodplain vegetation was positively associated with the presence of *Diarrhena obovata* (obovate beakgrain, DIOB3), *Diarrhena americana* (American beakgrain, DIAM), and *Bromus nottowayanus* (satin brome, BRNO). Despite a positive, albeit weak correlation between areal percent cover of rare species and percent cover of invasive species (Figure 8), there were no rare species found at the positive end of the invasive species richness vector with the exception of *Pedicularis lanceolata* (swamp lousewort, PELA2). The presence of *Prunus americana* (American plum, PRAM), *Lobelia spicata* (pale-spiked lobelia, LOSP), and *Carex argyrantha* (silver sedge, CAAR4), however, were found to be negatively associated with invasive species richness indicating that these species are likely to be found in habitats with few to no invasive species or dominant species and as a result, may be more sensitive to disturbance.

Several species were found to be positively associated with oak dominated habitats including *Dichanthelium latifolium* (broadleaf rosette grass, DILA8), *Oxalis violacea* (violet woodsorrel,

OXVI), *Viola palmata* (early blue violet, VIPA18), *Cynoglossum virginianum* var. *virginianum* (wild comfrey, CYVIV), *Desmodium rotundifolium* (round-leaved tick-trefoil, DERO3), and *Oxalis grandis* (great woodsorrel, OXGR). These species are therefore also likely to appear together in similar habitats and away from human disturbance. Based on the proximity of species symbols in ordination space, several groupings of rare species were observed without any strong associations to any of the measured environmental parameters. For example, *Carex cephaloidea* (thinleaf sedge, CACE2), *Lespedeza hirta* (hairy lespedeza, LEHI2), and *Lespedeza frutescens* (shrubby lespedeza, LEFR5) were found to occur together as were the species, *Pycnanthemum muticum* (clustered mountainmint, PYMU), *Carex annectens* (yellowfruit sedge, CAAN6), and *Zizania aquatica* (annual wildrice, ZIAQ).

Spiranthes magnicamporum (Great Plains lady's tresses, SPMA5), *Gentianopsis crinita* (greater fringed gentian, GECR2), and *Symphyotrichum oolentangiense* (skyblue aster, SYOO) were found farthest away from other rare species assemblages in the ordination plot suggesting that these species are not strongly influenced by any one particular habitat or disturbance-based parameter and occur infrequently across the park.

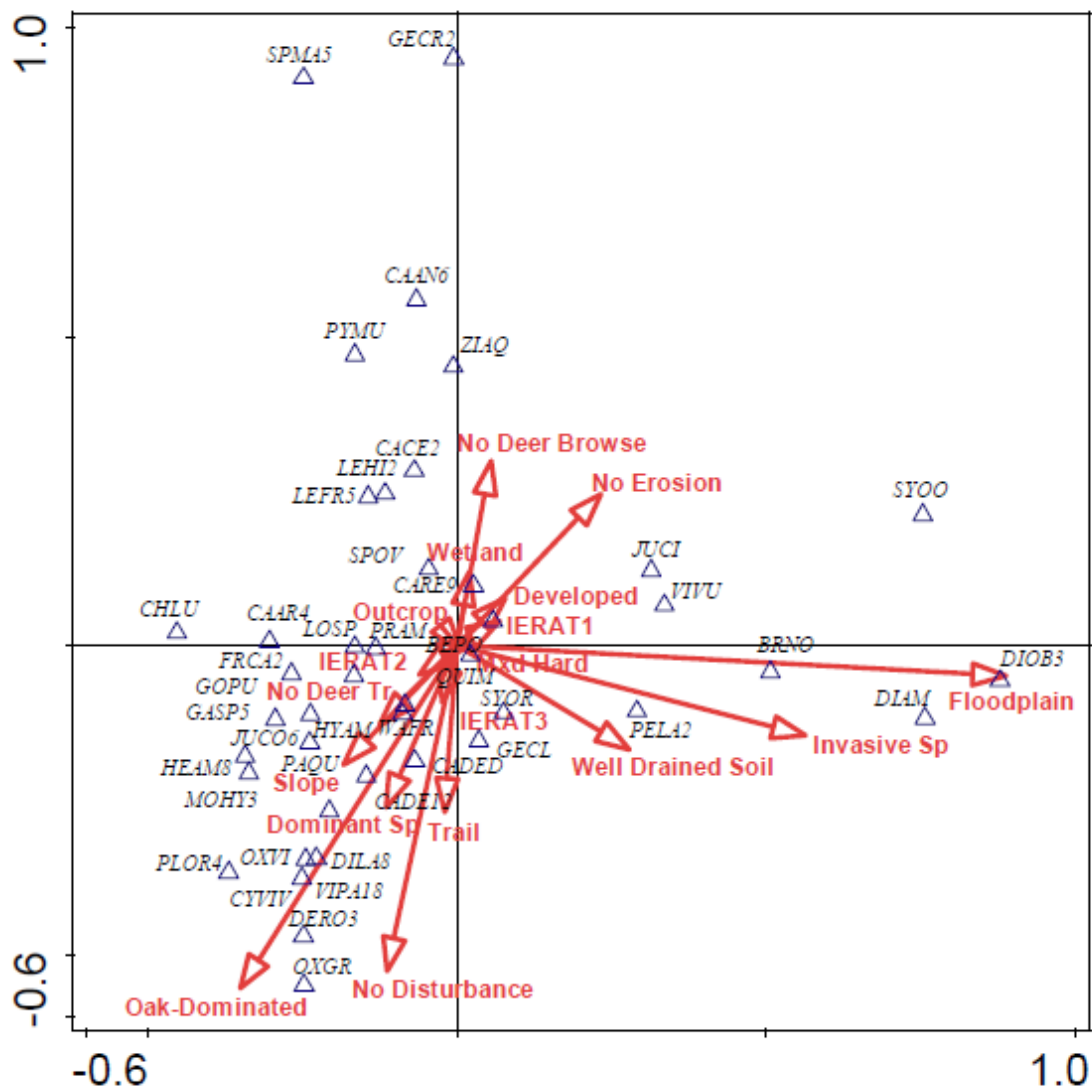


Figure 8. Canonical correspondence analysis ordination plot showing the relationship between the presence of rare plant species and environmental variation across all surveyed management zones in CUA. The x-axis represents CCA axis 1 and the y-axis represents CCA axis 2 which explained 17.1% and 13.6% of the variation in the model. Rare species are represented by blue triangles (see Appendix 1 for key to species codes). Symbols in proximity correspond to species often occurring together. The environmental variables are represented by red arrows. The angle between arrows indicates the correlation between individual environmental variables. The length of the arrow indicates the relative importance of a particular environmental variable, whereas the proximity of a species symbol to a given arrow indicates the taxon's association (positive if in the same direction as the arrow) with that environmental variable.

Results of the GIS Habitat Model

The GIS habitat model proved to be a poor predictor of rare plant occurrences. Probabilities of 2021 rare plant occurrences ranged from approximately 0.17 to 0.72, with a mean of 0.50.

Challenges and Lessons Learned

A number of lessons learned during the field survey are discussed below.

Training Lessons

Lead botanists at EnviroScience developed a comprehensive list of data fields and associated attributes for collection at each rare plant encounter. All botanists on the survey team were required to undergo data collection training with a lead botanist. Training included a discussion of the data fields and how to collect the data using the GPS followed by at least two days of training in the park with a lead botanist. Despite early training, some inconsistencies and deficiencies in data collection were noted during the data review process. The most notable example of this was insufficient documentation of diagnostic characteristics. When combined with poor-quality photo-vouchers, some records could not be independently verified after the fact. More frequent additional training throughout the field season could have helped calibrate data collection across all botanists involved in the survey. This would have provided a check system to ensure complete and consistent data collection throughout the sampling season.

Photo-voucher Data Collection

Review of photo-vouchers after the conclusion of field sampling revealed several issues. These include records with only a single photo-voucher submission, overview photographs instead of closeups, a lack of photographs identifying diagnostic features of the plant, and some poor-quality photographs. These issues resulted in insufficient documentation for some records, making it impossible to independently verify the identification. A small sample of photo-vouchers were reviewed during the field season and field botanists were made aware of these issues. While photo-voucher quality improved after this review, this was not the case for all field botanists. Reviewing photo-voucher submissions multiple times throughout the season could have minimized these issues by identifying problems early and rectifying them to ensure quality data was collected for each rare plant record. This would have also revealed which botanists continued to collect sub-par photographs after the initial feedback, which would have allowed for additional steps to be taken to correct the issue. In addition, it would be beneficial to require a minimum number of photographs per record.

Botanist Experience Level and Success Rate

The experience level of botanists included in this survey effort was variable. In addition to the experienced botanists at EnviroScience, the survey team included seasonal interns. On average, botanists completed 1.7 transects per hour; however, there was a difference in the time taken to complete transects, plants encountered, and records identified between experienced botanists and less experienced botanists. More experienced botanists tended to spend more time on data collection and have higher quality photo-vouchers.

Seasonality and Sampling Constraints

Originally, the plan was to visit certain areas within the park predicted to have specific types of rare plant species at the peak bloom time. However, the size of the project put constraints on the ability to reach those sites during peak bloom time, and only 10% of the transects were re-visited. Many transects completed early in the sampling season were not re-visited and have the potential to contain undocumented rare plant occurrences. Conversely, transects surveyed at the end of the season have

the potential to contain early blooming species that were missed due to the season in which the transect was visited. Overall, seasonality was an enormous constraint on the ability to visit transects during peak growing time for the target species. Re-visiting every transect in a single growing season was not possible given the number of transects and the size of the field crew.

Terrain and Sampling

The terrain of CUVA impacted efficiency along some transects. The sheer slopes in some areas caused the length of time spent on certain transects to increase dramatically in order to safely ascend and descend the slopes. Additionally, rainy weather caused these slopes to be slick which further increased time spent navigating the transect line. In some instances, this meant that the botanist needed to stray from the transect line for safety reasons to find an alternative pathway up or down before going back to the transect. In these cases the alternative path was surveyed in order to keep the total surveyed area within the park as consistent as possible. This sometimes resulted in records collected outside of the belt transects that would have otherwise been missed.

Office Coordination

In June, one of the full-time botanists was no longer able to survey in the field and was appointed the role of office coordinator for this project. Their main role was to schedule and assign a group of transects, meanders, and re-visits to each member of the survey team. In addition, the office coordinator kept track of which transects were visited using an internal tracking system, answered questions, helped troubleshoot issues for the survey team, and prepared GPS data for analysis. Overall, having an office coordinator was pivotal to finishing the survey component of this project on time.

IERAT Adjustments

The IERAT was designed to assess populations of *Lumbricus* spp. but was utilized to assess *Amyntas* spp. for this survey as well. This was done by ignoring references to middens within the dichotomous key and assessing severely impacted areas by the amount of castings and the impacts to the organic content within the soil. An additional field that specified whether the presence of *Lumbricus* spp. or *Amyntas* spp. were confirmed would have provided additional information on the relative population dynamics and distribution of the two genera.

The data dictionary on the GPS units utilized a dropdown list for IERAT score, requiring the botanist to select a number from 1 through 5. However, the IERAT is designed to assess earthworm populations specifically within eastern forested habitat. Data collection could have been improved by adding an option for “N/A” to account for areas where the IERAT cannot be assessed, such as open fields or wetlands. Because a score was required within the data dictionary utilized for this survey, the score of the nearest forested habitat was used at rare plant record locations where the IERAT could not be accurately assessed. Since earthworm infestations do not necessarily end at the forest edge, and most rare plant records where the IERAT could not be assessed are reasonably close to forested habitat, these assumed IERAT scores likely provide a good approximation of earthworm presence in the proximity of these rare plant records.

Belt Transects vs. Meander Surveys

Meander surveys were more successful in detecting rare plants than belt transects (21 percent versus 16 percent, respectively). However, the difference in success rates was not as high as expected, and we recommend that both methods be used in the future. If budget is limited, meander surveys, although less repeatable than transects, offer a greater chance of finding additional rare plant occurrences.

Access to Information about Historic Records

The 1986 Andreas report was not provided to EnviroScience until 2022, after the 2021 field work was complete. The information in this report would have been helpful to EnviroScience botanists in finding both new and historic records of rare plants. The details about CUVA-specific habitat affinities for rare plant species and descriptions of historical record locations would have been particularly useful. The habitat affinity descriptions have been reproduced in Appendix E of this document. Before any future rare plant surveys, we recommend the field botanists familiarize themselves with those habitat affinity descriptions.

While GIS data for historic records were loaded onto GPS units to assist in relocating those records, location data for records collected before the use of GPS technology (i.e., the Andreas survey) are imprecise. The locations for these records were presumably drawn onto topographic maps and/or recorded as coordinates estimated from topographic maps. When the records were digitized into GIS, further spatial errors may have been introduced depending on the digital topographic maps, satellite images, and/or coordinate systems used. Therefore, field botanists navigating to a specific point using a sub-meter accurate GPS unit likely did not end up at the exact location of the historic record. While expanded search areas around these records were surveyed by field botanists, the margin of error is inherently unknown. Some historic records may not have been relocated due to the spatial inaccuracies being larger than the field botanists accounted for.

Recommendations for Further Monitoring and Management

The 2021 survey was limited to a single growing season, which put limitations on the survey efforts. Both the time and the number of staff required to complete the surveys were estimated based upon previous transect surveys, which proved to be a gross underestimate of the amount of time needed to complete the 2021 survey. Therefore, the following recommendations have been provided for future survey and management efforts.

Efficient use of Botanist Experience Level

Future survey efforts could include two groups, a scouting group and a group of more experienced botanists. The scouting group could travel quickly and note locations of records on the GPS. These locations could then be visited by the more experienced botanists who would be tasked to collect the data and take photo-vouchers. This approach would ensure more consistent and higher-quality data collection at each rare plant record location.

Multiple Visits Across Seasons

Timing was the most limiting factor in detecting rare plants. In the future, surveying each transect more than once would allow species with different bloom times to be more easily detected along the

same transect. There are a number of ways that this can be accomplished. The park could be split into four or five sections and 20–25% of the park could be sampled intensively every year on a continuing basis. By having a smaller area to cover, transects could be surveyed more than once during the growing season. Moreover, this would ensure that future survey efforts include transect visits during a different season than when they were sampled in 2021. Alternatively, a subset of transects could be targeted for revisits and sampled multiple times throughout the growing season. These sampling approaches will hopefully lead to additional records by capturing species during peak bloom times.

Internal Surveys

Areas of interest where CUVA and Metroparks properties overlap could provide a unique survey opportunity. Personnel from each park could survey transects in areas of interest multiple times during the course of a growing season and compare data to identify hot spots within the park systems where species are located. Protection efforts can be coordinated to ensure maintenance of these populations. Additionally, it could provide unique study opportunities for local universities for students interested in plant ecology and conservation studies.

Data Collection at Areas without Rare Plants

One limitation to the survey design that became more apparent during analysis was that environmental data were only collected at locations at which rare plants occurred. Future studies could include some data collection points along transects where rare plants do not occur. The same environmental data (dominant species, invasive species, deer browse, human influence, IERAT, etc.) can be collected. A comparison of habitats both containing and not containing rare plant records could then be compared to potentially identify trends in habitat preference for rare plants. In addition, these data points could provide a unique opportunity to target areas where invasive species have become problematic so management plans can be developed. Earthworm movement trends could be identified, and high-intensity deer impacts can be targeted, especially if they are in close proximity to a rare plant record. We propose one data point along every other transect. If this data proves useful for management strategies within the park and time and funding are available, further data points can be added to provide a holistic sampling approach to the characterization of the park.

Changes to Unique Habitat Areas

The Columbia Run unique habitat area should be extended to the east and northeast to coincide with the boundary of the Columbia Sensitive Resources Zone. This additional area would include tributaries to Columbia Run and their associated steep ravine slopes, including some slumping and eroding slopes. Seeps are common on the lower slopes within these ravines, and one high-quality seep contains a population of *Hydrocotyle americana*. The mesic slope above this seep is where the only population of *Iris cristata* recorded during the 2021 survey was growing. Extending this unique habitat area would also capture records for several other species found along Columbia Run and nearby forested slopes.

We are not proposing any changes to the remaining existing unique habitat areas (Langes Run, Kendall Lake, Ritchie Ledges, Stumpy Basin Borrow Pit, Bike & Hike, North of Rt. 82, Station Rd Railroad Cut, Snowville Quarry, Blue Hen Falls, Valley Picnic Area, Oak Hill, Environmental Ed Center, and Wheatley Rd).

We propose a new unique habitat area surrounding the southern East Rim Trail and its southern parking lot, bounded by I-80 to the north, the Hike and Bike Trail to the east, and Boston Mills Road to the southwest, and including the open area south of the parking lot on the south side of Boston Mills Road, along the Hike and Bike Trail. Multiple records were found in this area of each of the following species: *Spiranthes magnicamporum*, *Corallorhiza odontorhiza*, *Gentianopsis crinita* and *Dichantheium latifolium*. The East Rim Trail, at the far south end of the Boston-Brandywine High Value Experience Area, was constructed after the Andreas survey. The new records found within this area are mostly species that tend to grow in disturbed areas with calcareous soils, which is habitat that is broadly similar to conditions found in the nearby Stumpy Basin. It is possible that erosion caused by trail installation improved habitat for these species. Further surveys for species that grow on calcareous soils and prefer mild to moderate disturbance, including the species found in 2021, would be worthwhile in this area. The populations found in 2021 should be monitored for impacts from visitor use and trail maintenance. One population of *Corallorhiza odontorhiza* consisting of several hundred plants was surrounded by unofficial anthropogenic trails and described by the field botanist as “clearly being trampled by wildflower viewers.” The amount of anthropogenic trails around a population of *Spiranthes magnicamporum* was described by the field botanist as “worrisome.” The showier species in this area are in danger of being loved to death. A plan to protect them from wildflower viewers should be developed and implemented. The needs of these species should be taken into consideration when planning trail maintenance, including vegetation management, erosion control, etc.

Conclusions

The systematic rare plant survey of CUVA is an important first step in updating the data set containing rare plant locations within the park. GIS modeling proved ineffective in determining priority areas for survey. Additional surveys in multiple seasons are recommended. Future efforts should include more robust and intensive sampling in areas with high concentrations of previous records, higher concentrations of 2021 occurrences, and unique, high-quality habitats within the park. Although systematic sampling using belt transects allows for coverage across the entire park, meander surveys may further prove to be beneficial in identifying rare plants. Future sampling efforts may identify threats to certain species and provide opportunities for population maintenance and management, and conservation efforts.

Literature Cited

- Andreas, B. K., J. J. Mack, and J. S. McCormac. 2004. Floristic Quality Assessment Index (FQAI) for vascular plants and mosses for the State of Ohio. Ohio Environmental Protection Agency, Division of Surface Water, Wetland Ecology Group, Columbus, Ohio. Pages 4–6.
- Benjamini, Y., and Y. Hochberg. 1995. Controlling the false discovery rate: a practical and powerful approach to multiple testing. *Journal of the Royal statistical society: series B (Methodological)*, 57(1), 289–300.
- Gauch, H. G., and H. G. Gauch Jr. 1982. *Multivariate analysis in community ecology* (No. 1). Cambridge University Press, New York.
- Hilty, J. 2021. Illinois Wildflowers. <https://www.illinoiswildflowers.info/>
- Loss S. R., R. M. Hueffmeier, C. M. Hale, G. E. Host, G. Sjerven, and L. E. Frelich. 2013. Earthworm Invasions in hardwood forests: a rapid assessment method. *Natural Areas Journal* 33:21–30.
- Michigan Flora Online. 2021. University of Michigan. LSA Herbarium. <https://michiganflora.net>.
- Minnesota Wildflowers, a field guide to the flora of Minnesota. Minnesota Environment and Natural Resources Trust Fund. <https://www.minnesotawildflowers.info/>
- Morgan, B. C., S. N. Bingham, C. C. Young, and J. L. Haack-Gaynor. Invasive exotic plant monitoring (year 2) for Cuyahoga Valley National Park. Natural Resource Data Series NPS/HTLN/NRDS—2018/1177. National Park Service, Fort Collins, Colorado.
- Native Plant Trust Go Botany. 2021. Discover thousands of New England Plants. New England Wild Flower Society. Dichotomous Key. <https://gobotany.nativeplanttrust.org/dkey/>
- ter Braak, C. J. F. and P. Smilauer. 2019. Canoco 5.12 (Software for multivariate data exploration, testing, and summarization).
- USDA, NRCS. 2021. The PLANTS Database (<http://plants.usda.gov>, various dates, 2021). National Plant Data Team, Greensboro, NC USA.
- Weakley, A. S. 2020. Flora of the southeastern United States. University of North Carolina Herbarium, North Carolina Botanical Garden. <https://ncbg.unc.edu/research/unc-herbarium/floras/>
- www.eFloras.org. Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico. 30 vols expected. New York and Oxford. (http://www.efloras.org/flora_page.aspx?flora_id=1) Vols. 1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 19, 20, 21, 22

Appendix A. Target species list

The target species list for the 2021 rare plant inventory.

Table A-1. Target species list.

Scientific Name	Common Name	USDA PLANTS Code	Status Ohio 2019
<i>Acer spicatum</i>	mountain maple	ACSP2	Not Listed
<i>Alopecurus aequalis</i>	shortawn foxtail	ALAE	Not Listed
<i>Anaphalis margaritacea</i>	pearly everlasting	ANMA	Not Listed
<i>Arabis canadensis</i>	sicklepod	ARCA	Not Listed
<i>Arabis hirsutus</i> var. <i>adipressipilis</i>	small hairy rock-cress	ARCA	Potentially Threatened
<i>Aralia spinosa</i>	devil's walking stick	ARSP2	Not Listed
<i>Asclepias exaltata</i>	poke milkweed	ASEX	Not Listed
<i>Asclepias quadrifolia</i>	four-leaved milkweed	ASQU	Not Listed
<i>Asclepias tuberosa</i>	butterfly milkweed	ASTU	Not Listed
<i>Asplenium trichomanes</i>	maidenhair spleenwort	ASTR2	Not Listed
<i>Aureolaria virginica</i>	downy yellow false foxglove	AUVI	Not Listed
<i>Baptisia tinctoria</i>	horseflyweed	BATI	Added
<i>Betula populifolia</i>	gray birch	BEPO	Not Listed
<i>Buxbaumia aphylla</i>	bug-on-a-stick	BUAP70	Threatened
<i>Calystegia spithamea</i>	upright bindweed	CASP14	Not Listed
<i>Capnoides sempervirens</i>	rock-harlequin	CASE16	Endangered
<i>Carex arctata</i>	drooping wood sedge	CAAR3	Threatened
<i>Carex argyrantha</i>	silver sedge	CAAR4	Potentially Threatened
<i>Carex atlantica</i>	prickly bog sedge	CAAT4	Potentially Threatened
<i>Carex aurea</i>	golden fruited sedge	CAAU3	Potentially Threatened
<i>Carex bebbii</i>	Bebb's sedge	CABE2	Potentially Threatened
<i>Carex cephaloidea</i>	thinleaf sedge	CACE2	Not Listed
<i>Carex crawei</i>	Crawe's sedge	CACR3	Not Listed
<i>Carex debilis debilis</i>	weak sedge	CADED	Not Listed
<i>Carex eburnea</i>	bristle-leaved sedge	CAEB2	Not Listed
<i>Carex hitchcockiana</i>	Hitchcock's sedge	CAHI8	Not Listed

Table A-1 (continued). Target species list.

Scientific Name	Common Name	USDA PLANTS Code	Status Ohio 2019
<i>Carex interior</i>	inland sedge	CAIN11	Not Listed
<i>Carex muhlenbergii</i>	Muhlenberg's sedge	CAMU4	Not Listed
<i>Carex oligocarpa</i>	sparse fruited sedge	CAOL2	Not Listed
<i>Carex prairea</i>	prairie sedge	CAPR6	Not Listed
<i>Carex retroflexa</i>	reflexed sedge	CARE9	Not Listed
<i>Carex shortiana</i>	Short's sedge	CASH2	Not Listed
<i>Carex stricta</i>	tussock sedge	CAST8	Not Listed
<i>Carex utriculata</i>	beaked sedge	CAUT	Not Listed
<i>Castanea dentata</i>	American chestnut	CADE12	Not Listed
<i>Castilleja coccinea</i>	scarlet Indian paintbrush	CACO17	Not Listed
<i>Ceanothus americanus</i>	New Jersey tea	CEAM	Not Listed
<i>Celastrus scandens</i>	American bittersweet	CESC	Not Listed
<i>Chaerophyllum procumbens</i>	spreading chervil	CHPR	Not Listed
<i>Chamaelirium luteum</i>	devil's bit	CHLU	Not Listed
<i>Chimaphilla umbellata</i>	pipsissewa	CHUM	Endangered
<i>Chrysogonum virginianum</i>	golden-knees	CHVI5	Threatened
<i>Circaea alpina</i>	small enchanter's nightshade	CIAL	Not Listed
<i>Clintonia umbellulata</i>	speckled wood-lily	CLUM2	Endangered
<i>Coleataenia anceps</i>	beaked panicgrass	COAN2	Not Listed
<i>Collinsia verna</i>	blue-eyed Mary	COVE2	Not Listed
<i>Corallorhiza maculata</i>	spotted coral-root	COMA25	Potentially Threatened
<i>Corallorhiza odontorhiza</i>	autumn coralroot	COOD7	Not Listed
<i>Cornus rugosa</i>	round-leaved dogwood	CORU	Potentially Threatened
<i>Cynoglossum virginianum</i> var. <i>virginianum</i>	wild comfrey	CYVIV	Not Listed
<i>Cypripedium acaule</i>	pink lady's slipper	CYAC3	Not Listed
<i>Cypripedium calceolus</i>	yellow lady's slipper	N/A	Not Listed
<i>Cypripedium candidum</i>	small white lady's-slipper	CYCA5	Threatened
<i>Cypripedium parviflorum</i> var. <i>pubescens</i>	large yellow lady's-slipper	CYPAP3	Not Listed
<i>Dactylorhiza viridis</i>	long-bracted orchid	DAVI6	Endangered

Table A-1 (continued). Target species list.

Scientific Name	Common Name	USDA PLANTS Code	Status Ohio 2019
<i>Deschampsia flexuosa</i>	crinkled hair grass	DEFL	Not Listed
<i>Desmodium rotundifolium</i>	round-leaved tick-trefoil	DERO3	Not Listed
<i>Diarrhena americana</i>	American beakgrain	DIAM	Not Listed
<i>Diarrhena obovata</i>	obovate beakgrain	DIOB3	Not Listed
<i>Dichanthelium acuminatum</i> ssp. <i>columbianum</i>	panic grass	DISAT / DICO12	Not Listed
<i>Dichanthelium commutatum</i>	panic grass	DICO2	Not Listed
<i>Dichanthelium depauperatum</i>	starved panic grass	DIDE4	Not Listed
<i>Dichanthelium latifolium</i>	broadleaf panic grass	DILA8	Not Listed
<i>Dichanthelium sphaerocarpon</i>	round-fruited panic grass	DISP2	Not Listed
<i>Digitaria cognata</i>	fall witchgrass	DICO6	Not Listed
<i>Doellingeria infirma</i>	cornel-leaf whitetop	DOIN2	Not Listed
<i>Dryopteris clintoniana</i>	Clinton's wood fern	DRCL	Endangered
<i>Eleocharis elliptica</i>	elliptic spikerush	ELEL4	Not Listed
<i>Elymus trachycaulus</i>	bearded wheat grass	ELTR7	Threatened
<i>Enchylium bachmanianum</i>	Bachman's jelly lichen	MD	Threatened
<i>Endodeca serpentaria</i>	Virginia snakeroot	ENSE4	Not Listed
<i>Equisetum variegatum</i>	variegated scouring-rush	EQVA	Endangered
<i>Eupatorium sessilifolium</i>	upland boneset	EUSE3	Not Listed
<i>Euphorbia corollata</i>	flowering spurge	EUCO10	Not Listed
<i>Euphorbia dentata</i>	green poinsettia	EUDE4	Not Listed
<i>Frasera caroliniensis</i>	American columbo	FRCA2	Not Listed
<i>Galearis spectabilis</i> (<i>Orchis spectabilis</i>)	showy orchis	ORSP2 / GASP5	Not Listed
<i>Gentiana clausa</i>	bottle gentian	GECL	Not Listed
<i>Gentianella quinquefolia</i>	stiff gentian	GEQU2	Not Listed
<i>Gentianopsis crinita</i>	fringed gentian	GECR2	Potentially Threatened
<i>Glyceria canadensis</i>	rattlesnake manna grass	GLCA	Not Listed
<i>Glyceria melicaria</i>	melic manna grass	GLME2	Not Listed
<i>Goodyera pubescens</i>	downy rattlesnake-plantain	GOPU	Not Listed

Table A-1 (continued). Target species list.

Scientific Name	Common Name	USDA PLANTS Code	Status Ohio 2019
<i>Helianthus microcephalus</i>	small woodland sunflower	HEMI3	Not Listed
<i>Hepatica americana</i>	round-lobed hepatica	HEAM8	Not Listed
<i>Houstonia canadensis</i>	Canadian summer bluet	HOCA5	Not Listed
<i>Hydrocotyle americana</i>	American water-pennywort	HYAM	Not Listed
<i>Hypericum ascyon (pyramidatum)</i>	great St. John's-wort	HYAM	Not Listed
<i>Hypericum majus</i>	tall St. John's-wort	HYMA2	Not Listed
<i>Iris cristata</i>	crested iris	IRCR	Not Listed
<i>Iris versicolor</i>	northern blue flag iris	IRVE2	Not Listed
<i>Isotria verticillata</i>	large whorled pogonia	ISVE	Potentially Threatened
<i>Juglans cinerea</i>	butternut	JUCI	Not Listed
<i>Juncus greenii</i>	Greene's rush	JUGR	Threatened
<i>Juniperus communis</i>	ground juniper	JUCO6	Endangered
<i>Lactuca floridana</i>	woodland lettuce	LAFL	Not Listed
<i>Lechea intermedia</i>	round-fruited pinweed	LEIN	Potentially Threatened
<i>Lespedeza frutescens</i>	violet bush clover	LEFR5	Not Listed
<i>Lespedeza hirta</i>	narrowleaf lespedeza	LEHI2	Not Listed
<i>Lespedeza procumbens</i>	trailing bush clover	LEPR	Not Listed
<i>Liatris aspera</i>	rough blazing star	LIAS	Not Listed
<i>Linum striatum</i>	stiff yellow flax	LIST	Not Listed
<i>Linum virginianum</i>	Florida yellow flax	LIVI	Not Listed
<i>Liparis lilifolia</i>	large twayblade	LILI3	Not Listed
<i>Liparis loeselii</i>	yellow widelip orchid	LILO	Not Listed
<i>Lobelia spicata</i>	pale-spiked lobelia	LOSP	Not Listed
<i>Lonicera canadensis</i>	American fly honeysuckle	LOCA7	Not Listed
<i>Lupinus perennis</i>	wild lupine	LUPE3	Potentially Threatened
<i>Maianthemum stellatum</i>	starry false Solomon's-seal	MAST4	Not Listed
<i>Melanthium virginicum</i>	bunchflower	MEVI2	Threatened
<i>Moehringia lateriflora</i>	bluntleaf sandwort	MOLA6	Potentially Threatened
<i>Monotropa hypopithys</i>	pinemap	MOLA6	Not Listed

Table A-1 (continued). Target species list.

Scientific Name	Common Name	USDA PLANTS Code	Status Ohio 2019
<i>Morus rubra</i>	red mulberry	MORU2	Not Listed
<i>Muhlenbergia sobolifera</i>	rock muhly	MUSO	Not Listed
<i>Myosotis verna</i>	early forget-me-not	MYVE	Not Listed
<i>Nabalus albus</i>	white rattlesnake-root	NAAL2	Not Listed
<i>Orobanche uniflora</i>	one-flowered cancer root	ORUN	Not Listed
<i>Orthilia secunda</i>	one-sided wintergreen	ORSE	Extirpated
<i>Oryzopsis asperifolia</i>	large-leaved mountain-rice	ORAS	Threatened
<i>Oxalis grandis</i>	great woodsorrel	OXGR	Not Listed
<i>Oxalis violaceae</i>	violet woodsorrel	OXVI	Not Listed
<i>Panax quinquefolius</i>	American ginseng	PAQU	Not Listed
<i>Parnassia glauca</i>	fen grass-of-Parnassus	PAGL3	Not Listed
<i>Pedicularis lanceolata</i>	swamp lousewort	PELA2	Not Listed
<i>Penstemon hirsutus</i>	hairy beardtongue	PEHI	Not Listed
<i>Phlox maculata</i>	spotted phlox	PHMA4	Not Listed
<i>Phlox pilosa</i>	downy phlox	PHPI	Not Listed
<i>Phlox subulata</i>	moss phlox	PHSU3	Not Listed
<i>Piptatherum racemosum</i>	mountain rice	PIRA5 / PARA2	Potentially Threatened
<i>Platanthera orbiculata</i>	Large Round Leaved Orchid	PLOR4	Not Listed
<i>Poa languida</i>	oldpasture bluegrass	POLA2 / POSAL	Not Listed
<i>Poa palustris</i>	fowl bluegrass	POPA2	Not Listed
<i>Polygala senega</i>	Seneca snakeroot	POSE3	Not Listed
<i>Potamogeton natans</i>	floating pondweed	PONA4	Potentially Threatened
<i>Prenanthes crepidinea</i>	nodding rattlesnake-root	PRCR	Not Listed
<i>Prunus americana</i>	American plum	PRAM	Not Listed
<i>Prunus pensylvanica</i>	fire cherry	PRPE2	Not Listed
<i>Pycnanthemum muticum</i>	blunt mountain-mint	PYMU	Not Listed
<i>Quercus imbricaria</i>	shingle oak	QUIM	Not Listed
<i>Ranunculus fascicularis</i>	early buttercup	RAFA	Threatened

Table A-1 (continued). Target species list.

Scientific Name	Common Name	USDA PLANTS Code	Status Ohio 2019
<i>Rhamnus alnifolia</i>	alder-leaved buckthorn	RHAL	Not Listed
<i>Rhexia virginica</i>	Virginia meadow-beauty	RHVI	Potentially Threatened
<i>Rhus aromatica</i> var. <i>aromatica</i>	fragrant sumac	RHARA2	Not Listed
<i>Salix humulis</i>	prairie willow	SAHU2	Not Listed
<i>Schoenoplectus americanus</i>	Onley's bulrush	SCAM6	Endangered
<i>Sericocarpus asteroides</i>	toothed whitetop aster	SEAS3	Not Listed
<i>Shepherdia canadensis</i>	Canada buffalo-berry	SHCA	Potentially Threatened
<i>Silphium laciniatum</i>	compass-plant	SILA3	Endangered
<i>Solidago squarrosa</i>	leafy goldenrod	SOSQ	Threatened
<i>Solidago ulmifolia</i>	elmleaf goldenrod	SOUL2	Not Listed
<i>Sphenopholis pennsylvanica</i>	swamp wedgescale	SPPE3	Not Listed
<i>Spiranthes lacera</i>	slender ladies' tresses	SPLA4	Not Listed
<i>Spiranthes lucida</i>	shining ladies' tresses	SPLU2	Potentially Threatened
<i>Spiranthes magnicamporum</i>	Great Plains ladies' tresses	SPMA5	Potentially Threatened
<i>Spiranthes ovalis</i>	lesser ladies' tresses	SPOV	Not Listed
<i>Spiranthes tuberosa</i>	little ladies' tresses	SPTU	Not Listed
<i>Sporobolus michauxianus</i>	prairie cordgrass	SPMI3 / SPPE	Not Listed
<i>Symphiocarpus orbiculatus</i>	coralberry	SPMI3 / SPPE	Not Listed
<i>Symphotrichum oolentangiensis</i>	sky blue aster	SYOO	Not Listed
<i>Taxus canadensis</i>	Canada yew	TACA7	Potentially Threatened
<i>Triglochin maritima</i>	seaside arrowgrass	TRMA20	Threatened
<i>Valerianella chenopodiifolia</i>	goosefoot cornsalad	VACH	Not Listed
<i>Vicia americana</i>	American vetch	VIAM	Endangered
<i>Vicia caroliniana</i>	white wood vetch	VICA2	Not Listed
<i>Viola palmata</i>	early blue violet	VIPA18	Not Listed
<i>Viola sagittata</i> var. <i>ovata</i>	arrowleaf violet	VISAO	Not Listed
<i>Vitis vulpina</i>	frost grape	VIVU	Not Listed
<i>Waldsteinia fragarioides</i>	Appalachian barren strawberry	WAFR	Not Listed

Table A-1 (continued). Target species list.

Scientific Name	Common Name	USDA PLANTS	Status Ohio 2019
		Code	
<i>Zizania aquatica</i>	wild rice	ZIAQ	Threatened
<i>Zizania palustris</i>	wild rice	ZIPA3	Threatened

Appendix B. Description of GIS habitat model

Modeling predicated rare plant localities at Cuyahoga Valley National Park

We modeled predicted plant localities at Cuyahoga Valley National Park in order to assist in determining optimal locations for transect surveys. Models were developed using rare plant data locality data from multiple sources. Environmental covariates used for modeling were selected based upon local knowledge of ecology and factors assumed to influence plant distributions including both environmental and physical characteristics.

Plant locality data were obtained from the National Park Service, Ohio Division of Natural Areas and Preserves, and the Global Biodiversity Information Facility (GBIF) open-source repository. Point localities from all sources were combined into a single data set. Smaller subsets of plant locality data were generated based upon environmental and physical characteristics for plant species including data sets comprised of species preferring sandy soils, wetland species, species associated with forests, acidophiles, and calciphiles. Additional data subsets were also created for spring, early summer, and late summer bloom phenologies. We created a random set of localities across the Cuyahoga Valley National Park property to use as “background” points against which to compare known plant localities. The number of points used in each model was dependent upon the number of plant localities in each subset and varied from approximately 40 to 300 random points.

We derived and rasterized environmental and physical datasets for use in models. Environmental covariates included distance to nearest wetland, distance to nearest stream, distance to nearest spring, and distance to the nearest rock outcrop. Most physical habitat characteristics were derived from a 30 m digital elevation model and included slope, aspect, and topographic wetness index (TWI). While factors such as soils invariably are a component of habitat suitability for plants, soil variables were excluded due to the complexity of the SSURGO dataset. Instead, we used soil associations as a category for plant species locality datasets. All raster datasets were comprised of 30 m x 30 m pixels. For each plant locality, raster values were extracted.

We used a multi-model inference with an information theoretic approach and model averaging to model environmental and physical habitat characteristics for each subset of plant locality data. For modeling purposes, plant localities were considered a “presence” (1), while background points were considered an “absence” (0). We used the `glmulti` package in the statistical program R to run model sets for each subset of plant locality data. Variable importance and weighting for parameter estimates were based upon the number of models within the resulting model set in which an individual variable was included. Additionally, variables with parameter estimates and associated 95% confidence intervals that intersected zero were generally considered non-important. For each model set, a resulting rasterized probabilistic representation of predicted suitable habitat was created using the raster calculator function and logit link function. Due to the use of model averaging to derive parameter estimates, all variables were included in the resulting probability calculation even if considered non-important. An additional raster representing a mean of all model set results was also created by averaging the probabilities for each cell across models. While we did not directly test

model fit, a visual assessment of known plant localities relative to predicted suitable habitat appears to indicate suitable fit of the individual models as well as the mean of model.

An example of the logit link function equation used to calculate rasterized model results is presented below.

```
Model for Sandy Soils: ((2.71828 ^ (-0.70948 + ("twi@1" *
0.01689) + ("rockoutcrop@1" * -0.00072) + ("springs@1" *
-0.00001) + ("aspect@1" * 0.00002)+("slope@1" * 0.0297)+
("wetlands@1" * -0.00077) + ("streams@1" * 0.00488)))) / (1 +
((2.71828 ^ (-0.70948 + ("twi@1" * 0.01689) + ("rockoutcrop@1"
* -0.00072) + ("springs@1" * -0.00001) + ("aspect@1" *
0.00002)+("slope@1" * 0.0297)+ ("wetlands@1" * -0.00077) +
("streams@1" * 0.00488))))
```

```
M=(INT+("twi@1" * cTWI) + ("rockoutcrop@1" * cROC) +
("springs@1" * cSPR)+ ("aspect@1" * cASP)+ )+("slope@1" *
cSLO) + ("wetlands@1" * cWET) + ("streams@1" * cSTR)
```

```
F(n)=e^M/(1+e^M)
```

Initial models included two additional variables, distance to roads and distance to trails. It became obvious, however, that plant locality data were biased due to ease of access due to trails and roads, resulting in model sets strongly driven by close proximity to trails and roads. Due to this obvious bias, these factors were dropped from consideration in models and all model sets were re-run without these two variables. Results of models are presented in Table B-1 below. Variable importance differed across plant locality datasets. Predicted habitat suitability generally related to environmental factors such as distance from streams, wetland, rock outcrops, and springs more so than physical characteristics such as aspect and TWI.

Table B-1. Results of multi-model inference using an information theoretic approach with model averaging across the entire model set. n = the number of plant localities included in the model; an approximately equal number of random locations were included in each model.

Variable Type	Variable	Variable Code	Sandy	Wetlands (n = 72)	Forests (n = 364)	Acidophiles (n = 26)	Calciphiles (n = 94)
			Soils (n = 186)				
Intersect	Model Intersect	INT	-0.7095	0.20446	0.02028	-1.1817	-0.3855
Environmental	Distance to Spring	cSPR	-1E-05	0.00004	0.00002	-0.0008 ^A	0
	Distance to Stream	cSTR	0.00488 ^A	-8E-05	0.00136	-0.0023	0.00423 ^A
	Distance to Wetland	cWET	-0.0008	-0.0054 ^A	-0.0041 ^A	-0.0003	-0.0033 ^A
	Distance to Rock Outcrop	cROC	-0.0007 ^A	-0.0008 ^A	-0.0011 ^A	-5E-05	-0.0002
Physical	Slope	cSLO	0.0297	-0.0029	0.04072 ^A	0.01151	0.00867
	Aspect	cASP	0.0002	0.00076	0.00066	0.0007	0.00073
	Topographic Wetness Index	cTWI	0.01689	0.06422	0.01447	0.14765 ^B	-0.0007

^A Important variables for each model are presented in bold.

^B Variable with confidence interval that only slightly overlaps 0, implying weak support for potential variable importance.

Appendix C. Variables used in data analysis

Tables C1–C4 describe the variables used in data analysis.

Table C-1. Summary of 2021 rare plant population and species parameters for management zones in CUVA. Means are reported with $\pm$ standard error, where applicable. No rare plants were found in the Boston Mills Historic District Zone, Coliseum Natural Zone, Peninsula High Value Recreation Zone, or Snowville Natural Zone, so they are excluded from this table.

Management Zone	Size (ac)	Total Number of Rare Species Records	Rare Species Richness	Mean Population Size of Rare Species	Mean Rare Species Population Density (#/m ²)	Mean Percent Areal Cover of Rare Species	Invasive Species Richness	Mean Percent Cover of Invasive Species	Dominant Species Richness
Adams Run Natural Zone	1329	14	8	29.36 $\pm$ 11.83	2.14 $\pm$ 0.66	2.21 $\pm$ 0.74	4	2.93 $\pm$ 1.41	11
A-P North Sensitive Resources Zone	1437.1	142	36	31.37 $\pm$ 7.21	3.33 $\pm$ 0.82	4.83 $\pm$ 1.23	13	3.82 $\pm$ 0.69	31
Bath Road to Peninsula River Corridor Zone	1463.2	30	8	187.07 $\pm$ 166.03	3.36 $\pm$ 1.17	10.04 $\pm$ 3.31	14	34.72 $\pm$ 3.81	14
Blossom Woods Natural Zone	2896	105	35	48.95 $\pm$ 15.32	4.69 $\pm$ 1.39	3.16 $\pm$ 0.75	15	6.98 $\pm$ 1.12	27
Blue Hen Falls Natural Zone	136.7	5	4	11.20 $\pm$ 3.79	2.6 $\pm$ 0.68	1.62 $\pm$ 0.86	4	8.42 $\pm$ 2.84	4
Botzum Natural Zone	789.9	2	2	261.00 $\pm$ 239	9.20 $\pm$ 4.80	50.0 $\pm$ 35.0	4	13.50 $\pm$ 1.50	6
Canal Cultural High Value Experience Zone	302.1	2	2	40.50 $\pm$ 39.50	2.50 $\pm$ 1.50	30.0 $\pm$ 20.0	3	52.0 $\pm$ 51.0	3
Columbia Sensitive Resources Zone	715.6	37	16	21.62 $\pm$ 4.43	4.42 $\pm$ 1.18	3.95 $\pm$ 1.66	11	5.36 $\pm$ 2.11	21
Everett Cultural High Value Experience Zone	1580	10	7	4.80 $\pm$ 1.47	3.25 $\pm$ 0.74	2.51 $\pm$ 0.68	7	6.90 $\pm$ 2.98	10
Furnace Run South - Oak Hill Natural Zone	4205.3	23	13	24.00 $\pm$ 17.25	2.32 $\pm$ 0.48	7.67 $\pm$ 3.02	11	11.53 $\pm$ 3.58	19
Interstate Natural Zone	142.3	2	1	6.00 $\pm$ 4.00	3.50 $\pm$ 1.50	10.00 $\pm$ 5.00	4	4.00 $\pm$ 3.00	1
NA—outside management zones	5353.3	34	21	36.59 $\pm$ 14.50	5.55 $\pm$ 1.84	10.09 $\pm$ 4.01	16	7.76 $\pm$ 2.58	26
Northern Natural Zone	1328.6	12	8	10.25 $\pm$ 3.98	3.72 $\pm$ 1.99	6.67 $\pm$ 4.02	12	11.42 $\pm$ 2.26	11
Old Carriage Natural Zone	701.2	11	6	103.00 $\pm$ 53.7	8.28 $\pm$ 3.55	11.77 $\pm$ 4.87	7	7.74 $\pm$ 2.43	8
Peninsula to Boston Mills River Corridor Zone	196.9	1	1	10	10	20	1	3	1

Table C-1 (continued). Summary of 2021 rare plant population and species parameters for management zones in CUVA. Means are reported with ± standard error, where applicable. No rare plants were found in the Boston Mills Historic District Zone, Coliseum Natural Zone, Peninsula High Value Recreation Zone, or Snowville Natural Zone, so they are excluded from this table.

Management Zone	Size (ac)	Total Number of Rare Species Records	Rare Species Richness	Mean Population Size of Rare Species	Mean Rare Species Population Density (#/m²)	Mean Percent Areal Cover of Rare Species	Invasive Species Richness	Mean Percent Cover of Invasive Species	Dominant Species Richness
Pinery Narrows/Twin Sisters Sensitive Resource Zone	348.9	5	5	8.80 ± 5.38	2.40 ± 0.98	2.00 ± 1.00	4	5.00 ± 1.58	5
Snowville Woods Natural Zone	2094.7	14	7	66.79 ± 36.41	4.56 ± 2.08	4.57 ± 1.64	9	16.11 ± 6.32	12
Stanford Run /Hines Hill High Value Experience Zone	2173.6	65	24	44.14 ± 9.83	4.39 ± 1.01	7.06 ± 1.50	10	15.33 ± 2.1	35
Station Road to Boston Mills River Corridor Zone	842.1	37	8	35.11 ± 8.1	3.69 ± 0.79	6.65 ± 2.04	14	23.99 ± 2.99	18
Station Road to Rockside River Corridor Zone	740.9	7	3	20.57 ± 13.6	2.64 ± 0.88	9.00 ± 3.57	5	19.64 ± 8.17	5
Terra Vista Natural Zone	264	2	1	11.50 ± 1.50	0.48 ± 0.33	0.75 ± 0.25	3	6.00 ± 2.5	3
Twin Sisters-Mudcatcher Sensitive Resource Zone	232.8	4	3	4.25 ± 1.97	2.75 ± 1.75	2.50 ± 1.19	3	7.50 ± 1.44	4
Virginia Kendall High Value Experience Zone	2889.4	111	33	28.09 ± 9.65	2.67 ± 0.46	9.51 ± 1.77	15	11.23 ± 1.75	54

Table C-2. Summary of 2021 rare plant population and species parameters for priority zones in CUVA. Means are reported with $\pm$ standard error, where applicable.

Priority Zone	Size (ac)	Total Number of Rare Species Records	Rare Species Richness	Mean Population Size of Rare Species	Mean Rare Species Population Density (#/m ²)	Mean Percent Areal Cover of Rare Species	Invasive Species Richness	Mean Percent Cover of Invasive Species	Dominant Species Richness
A-P North Sensitive Resources Zone	1689	50	50	29.34 $\pm$ 7.59	2.44 $\pm$ 0.44	3.11 $\pm$ 1.57	45	3.85 $\pm$ 1.55	94
Blossum Woods Natural Zone	2896	103	103	49.33 $\pm$ 15.61	4.71 $\pm$ 1.41	2.88 $\pm$ 0.7	132	7.07 $\pm$ 1.14	235
Boston-Brandywine High Value Experience Zone	2202	62	62	39.26 $\pm$ 9.64	4.38 $\pm$ 1.06	7.26 $\pm$ 1.57	90	15.27 $\pm$ 2.18	114
Columbia Run Unique Habitat Area	66	11	11	22.45 $\pm$ 7.71	8.22 $\pm$ 3.74	0.49 $\pm$ 0.11	6	0.13 $\pm$ 0.06	21
Columbia Sensitive Resources Zone	785	31	31	19.65 $\pm$ 4.67	2.78 $\pm$ 0.31	4.8 $\pm$ 1.95	40	7.72 $\pm$ 2.47	50
Kendall Lake Unique Habitat Area	36	25	25	25.4 $\pm$ 8.96	2.09 $\pm$ 0.69	5.93 $\pm$ 2.84	58	7.55 $\pm$ 1.51	60
Langes Run Unique Habitat Area	7	1	1	9 $\pm$ 0	1 $\pm$ 0	0.1 $\pm$ 0	0	0	2
NA—Outside Priority Zone	96	210	210	60.16 $\pm$ 24.33	3.96 $\pm$ 0.47	8.03 $\pm$ 1.1	353	16.15 $\pm$ 1.35	365
North of Rt. 82 Unique Habitat Area	4	1	1	6 $\pm$ 0	3 $\pm$ 0	1 $\pm$ 0	0	0	3
Ritchie Ledges Unique Habitat Area	137	7	7	8.14 $\pm$ 2.73	1.81 $\pm$ 0.7	11.16 $\pm$ 5.89	6	0.73 $\pm$ 0.41	14
Stumpy Basin Borrow Pit Unique Habitat Area	214	96	96	31.35 $\pm$ 9.95	3.75 $\pm$ 1.17	5.54 $\pm$ 1.62	96	3.69 $\pm$ 0.64	162
Virginia Kendall High Value Experience Zone	2637	76	76	32.29 $\pm$ 13.78	2.99 $\pm$ 0.62	11.36 $\pm$ 2.36	119	13.87 $\pm$ 2.44	144
Wheatley Rd Unique Habitat Area	33	2	2	3 $\pm$ 1	2 $\pm$ 1	1 $\pm$ 0	4	10.5 $\pm$ 0.5	2

Table C-3. Summary of 2021 habitat-based parameters for rare plant records in 23 management zones in CUVA. Means are reported with ± standard error, where applicable. No rare plants were found in the Boston Mills Historic District Zone, Coliseum Natural Zone, Peninsula High Value Recreation Zone, or Snowville Natural Zone, so they are excluded from this table.

Management Zone	Human Disturbance at Rare Plant Records				Percent of Deer Browse at Rare Plant Records				Number of Deer Trails at Rare Plant Records				IERAT Score at Rare Plant Records		Erosion Presence at Rare Plant Records				CoC	
	Mean Score	Qualitative Value (based on mean)	Mode	Qualitative Rank (based on mode)	Mean Percent	Qualitative Value (based on mean)	Mode	Qualitative Value (based on mode)	Mean Number	Qualitative Value (based on mean)	Mode	Qualitative Value (based on mode)	Mean Score	Mode	Mean Score	Qualitative Value (based on mean)	Mode	Qualitative Value (based on mode)	Mean Score	Mode
Adams Run Natural Zone	0.6 ± 0.2	Some	0	None	17.9 ± 7.1	Some	0	None	0.6 ± 0.1	Some	1	Some	2.4 ± 0.2	3	0.2 ± 0.2	None	0	None	5.9 ± 0.3	6
A-P North Sensitive Resources Zone	0.4 ± 0.1	None	0	None	24.8 ± 1.2	Some	25	Some	0.7 ± 0.1	Some	1	Some	3.4 ± 0.1	5	0.5 ± 0.1	None	0	None	6.1 ± 0.1	5
Bath Road to Peninsula River Corridor Zone	0.5 ± 0.2	Some	0	None	20 ± 2.8	Some	25	Some	0.7 ± 0.1	Some	1	Some	3.4 ± 0.2	4	0.1 ± 0.1	None	0	None	6.6 ± 0.2	7
Blossom Woods Natural Zone	0.3 ± 0.1	None	0	None	20.2 ± 1.3	Some	25	Some	0.5 ± 0.1	Some	0	None	3.2 ± 0.1	2	0.3 ± 0.1	None	0	None	5.6 ± 0.1	6,7
Blue Hen Falls Natural Zone	0.8 ± 0.4	Some	0,1	None, Some	25	Some	25	Some	0.2 ± 0.2	None	0	None	3.6 ± 0.2	4	0.2 ± 0.2	None	0	None	4.8 ± 0.9	3,7
Botzum Natural Zone	0	None	0	None	37.5 ± 37.5	Some	0,75	None, Extensive	1	Some	1	Some	3 ± 2	1,5	0	None	0	None	6 ± 1	5,7
Canal Cultural High Value Experience Zone	1.5 ± 0.5	Extensive	1,2	Some, Extensive	50 ± 25	Extensive	25,75	Some, Extensive	1	Some	1	Some	3	3	0.5 ± 0.5	Some	0,1	None, Some	4 ± 1	3,5
Columbia Sensitive Resources Zone	0.7 ± 0.1	Some	0,1	None, Some	22.3 ± 1.3	Some	25	Some	0.6 ± 0.1	Some	1	Some	3.4 ± 0.2	3	0.2 ± 0.1	None	0	None	5.1 ± 0.2	6
Everett Cultural High Value Experience Zone	0.3 ± 0.2	None	0	None	15 ± 4.1	Some	25	Some	0.5 ± 0.2	Some	0,1	None, Some	2.9 ± 0.4	4	0.5 ± 0.2	Some	0,1	None, Some	6 ± 0.2	6
Furnace Run South - Oak Hill Natural Zone	0.8 ± 0.2	Some	0,1	None, Some	27.2 ± 2.2	Some	25	Some	1 ± 0.1	Some	1	Some	3.1 ± 0.2	3	0.4 ± 0.1	None	0	None	5.6 ± 0.3	7
Interstate Natural Zone	0.5 ± 0.5	Some	0,1	None, Some	25 ± 0	Some	25	Some	1	Some	1	Some	3.5 ± 0.5	3,4	1 ± 1	Some	0,2	None, Extensive	3 ± 0	3
NA—outside management zones	0.7 ± 0.1	Some	0	None	19.8 ± 3.6	Some	25	Some	0.6 ± 0.1	Some	0	None	3.1 ± 0.3	5	0.4 ± 0.1	None	0	None	5.4 ± 0.4	7
Northern Natural Zone	1.3 ± 0.2	Some	1	Some	33.3 ± 5.6	Some	25	Some	0.8 ± 0.2	Some	1	Some	3 ± 0.4	2	0.1 ± 0.1	None	0	None	4.2 ± 0.4	3
Old Carriage Natural Zone	0.7 ± 0.2	Some	0	None	25 ± 5.8	Some	25	Some	1.1 ± 0.2	Some	1	Some	3 ± 0.4	4	0.6 ± 0.2	Some	0,1	None, Some	5.7 ± 0.4	7
Peninsula to Boston Mills River Corridor Zone	1	Some	1	Some	25	Some	25	Some	1	Some	1	Some	4	4	0	None	0	None	7	7
Pinery Narrows/Twin Sisters Sensitive Resource Zone	0.2 ± 0.2	None	0	None	25 ± 13.7	Some	0,25	None, Some	0.8 ± 0.4	Some	0,1	None, Some	2.2 ± 0.4	2,3	0.4 ± 0.4	None	0	None	4.8 ± 0.7	4
Snowville Woods Natural Zone	0.9 ± 0.2	Some	0,1	None, Some	16.1 ± 3.3	Some	25	Some	0.6 ± 0.1	Some	1	Some	3.3 ± 0.3	3	0.2 ± 0.1	None	0	None	5.9 ± 0.4	6
Stanford Run /Hines Hill High Value Experience Zone	0.5 ± 0.1	Some	0	None	21.2 ± 2.9	Some	25	Some	0.5 ± 0.1	Some	0	None	3.4 ± 0.2	3	0.2 ± 0.1	None	0	None	5.8 ± 0.2	7
Station Road to Boston Mills River Corridor Zone	0.7 ± 0.1	Some	0	None	23.6 ± 3.9	Some	25	Some	0.7 ± 0.1	Some	1	Some	3.0 ± 0.2	3	0.1 ± 0.04	None	0	None	6.8 ± 0.2	7

Table C-3 (continued). Summary of 2021 habitat-based parameters for rare plant records in 23 management zones in CUVA. Means are reported with ± standard error, where applicable. No rare plants were found in the Boston Mills Historic District Zone, Coliseum Natural Zone, Peninsula High Value Recreation Zone, or Snowville Natural Zone, so they are excluded from this table.

Management Zone	Human Disturbance at Rare Plant Records				Percent of Deer Browse at Rare Plant Records			Number of Deer Trails at Rare Plant Records				IERAT Score at Rare Plant Records		Erosion Presence at Rare Plant Records			CoC			
	Mean Score	Qualitative Value (based on mean)	Mode	Qualitative Rank (based on mode)	Mean Percent	Qualitative Value (based on mean)	Mode	Qualitative Value (based on mode)	Mean Number	Qualitative Value (based on mean)	Mode	Qualitative Value (based on mode)	Mean Score	Mode	Mean Score	Qualitative Value (based on mean)	Mode	Qualitative Value (based on mode)	Mean Score	Mode
Station Road to Rockside River Corridor Zone	0.7 ± 0.4	Some	0	None	7.1 ± 4.6	None	0	None	0.3 ± 0.2	None	0	None	2 ± 0.4	1	0.3 ± 0.2	None	0	None	6 ± 1	7
Terra Vista Natural Zone	1.5 ± 0.5	Extensive	1,2	Some, Extensive	25	Some	25	Some	0	None	0	None	4	4	0	None	0	None	3	3
Twin Sisters-Mudcatcher Sensitive Resource Zone	0	None	0	None	37.5 ± 21.6	Some	0,75	None, Extensive	1	Some	1	Some	1.5 ± 0.3	1,2	0.5 ± 0.3	Some	0,1	None, Some	6.2 ± 0.2	6
Virginia Kendall High Value Experience Zone	0.7 ± 0.1	Some	0	None	22.5 ± 1.4	Some	25	Some	0.3 ± 0.04	None	0	None	2.8 ± 0.1	4	0.2 ± 0.04	None	0	None	5.6 ± 0.2	5

Table C-4. Summary of 2021 habitat-based parameters for rare plant records in 12 priority zones in CUVA. Means are reported with ± standard error, where applicable.

Priority Zone	Human Disturbance at Rare Plant Records			Percent of Deer Browse at Rare Plant Records				Number of Deer Trails at Rare Plant Records				IERAT Score at Rare Plant Records			Erosion Presence at Rare Plant Records			CoC		
	Mean Score	Qualitative Value (based on mean)	Mode	Qualitative Value (based on mode)	Mean Percent	Qualitative Value (based on mean)	Mode	Qualitative Value (based on mode)	Mean Number	Qualitative Value (based on mean)	Mode	Qualitative Value (based on mode)	Mean Score	Mode	Mean Score	Qualitative Value (based on mean)	Mode	Qualitative Value (based on mode)	Mean Score	Mode
A-P North Sensitive Resources Zone	0.3 ± 0.1	None	0	None	27 ± 2.6	Some	25	Some	0.4 ± 0.1	None	0	None	3 ± 0.1	3	0.2 ± 0.1	None	0	None	5.5 ± 0.1	5
Blossom Woods Natural Zone	0.3 ± 0.1	None	0	None	20.1 ± 1.3	Some	25	Some	0.5 ± 0.1	Some	0	None	3.2 ± 0.1	4	0.3 ± 0.1	None	0	None	5.6 ± 0.1	7
Boston-Brandywine High Value Experience Zone	0.5 ± 0.1	Some	0	None	22.2 ± 3	Some	25	Some	0.5 ± 0.1	Some	0	None	3.4 ± 0.2	3	0.2 ± 0.1	None	0	None	5.7 ± 0.2	7
Columbia Run	0.6 ± 0.2	Some	1	Some	20.5 ± 3	Some	25	Some	0.1 ± 0.1	None	0	None	3.6 ± 0.3	3	0.3 ± 0.1	None	0	None	5.7 ± 0.2	6
Columbia Sensitive Resources Zone	0.7 ± 0.1	Some	0	None	23.4 ± 1.1	Some	25	Some	0.7 ± 0.1	Some	1	Some	3.3 ± 0.2	3	0.1 ± 0.1	None	0	None	4.9 ± 0.3	3
Kendall Lake	1.5 ± 0.1	Extensive	2	Extensive	23 ± 1.4	Some	25	Some	0.1 ± 0.1	None	0	None	2 ± 0.2	1	0.1 ± 0.1	None	0	None	6.2 ± 0.3	5
Langes Run	0	None	0	None	25	Some	25	Some	0	None	0	None	2	2	1	Some	1	Some	4	4
NA—Outside Priority Zone	0.7 ± 0.1	Some	0	None	21.8 ± 1.4	Some	25	Some	0.7 ± 0	Some	1	Some	3 ± 0.1	3	0.3 ± 0	None	0	None	5.9 ± 0.1	7
North of Rt. 82	0	None	0	None	75	Extensive	75	Extensive	1	Some	1	Some	1	1	2	Extensive	2	Extensive	4	4
Ritchie Ledges	1 ± 0.3	Some	1	Some	28.6 ± 8.5	Some	25	Some	0	None	0	None	2.9 ± 0.6	3	0.1 ± 0.1	None	0	—	8.4 ± 0.8	10
Stumpy Basin Borrow Pit	0.4 ± 0.1	None	0	None	23.7 ± 1.1	Some	25	Some	0.9 ± 0.1	Some	1	Some	3.6 ± 0.1	5	0.6 ± 0.1	Some	0	—	6.4 ± 0.2	8
Virginia Kendall High Value Experience Zone	0.4 ± 0.1	None	0	None	21.7 ± 1.9	Some	25	Some	0.4 ± 0.1	None	0	None	3 ± 0.1	4	0.2 ± 0	None	0	None	5.1 ± 0.2	3
Wheatley Rd	1 ± 0	Some	1	Some	25 ± 0	Some	25	Some	1 ± 0	Some	1	Some	4 ± 0	4	0.5 ± 0.5	Some	0,1	None, Some	7 ± 0	7

Appendix D. Rare plant occurrences in 2021

Tables D-1 and D-2 show rare plant occurrences in 2021.

Table D-1. Rare plant occurrences in 2021. One occurrence is defined as one location or polygon regardless of number of individuals found at that location. A superscript “A” indicates species of interest neither recorded historically nor found in 2021 survey.

Scientific Name	Historic Record?	Found in 2021?	Total 2021 Occurrences
<i>Acer spicatum</i>	–	Yes	1
<i>Alopecurus aequalis</i>	–	–	–
<i>Anaphalis margaritacea</i>	–	Yes	1
<i>Arabis canadensis</i> ^A	–	–	–
<i>Arabis hirsuta</i> var. <i>adpressipilis</i> ^A	–	–	–
<i>Aralia spinosa</i>	1	–	–
<i>Asclepias exaltata</i> ^A	–	–	–
<i>Asclepias quadrifolia</i>	–	Yes	1
<i>Asclepias tuberosa</i>	–	Yes	1
<i>Asplenium trichomanes</i>	2	–	–
<i>Aureolaria virginica</i>	1	Yes	3
<i>Baptisia tinctoria</i>	4	–	–
<i>Betula populifolia</i>	2	Yes	8
<i>Bromus nottowayanus</i>	10	Yes	54
<i>Buxbaumia aphylla</i>	3	–	–
<i>Calystegia spithamea</i>	–	Yes	2
<i>Capnoides sempervirens</i>	1	–	–
<i>Carex aggregata</i>	1	–	–
<i>Carex annectens</i>	1	–	–
<i>Carex arctata</i>	4	–	–
<i>Carex argyrantha</i>	16	Yes	5
<i>Carex atlantica</i>	3	–	–
<i>Carex aurea</i>	17	Yes	2
<i>Carex bebbii</i>	8	–	–
<i>Carex cephaloidea</i>	3	Yes	9

Table D-1 (continued). Rare plant occurrences in 2021. One occurrence is defined as one location or polygon regardless of number of individuals found at that location. A superscript “A” indicates species of interest neither recorded historically nor found in 2021 survey.

Scientific Name	Historic Record?	Found in 2021?	Total 2021 Occurrences
<i>Carex crawei</i>	4	–	–
<i>Carex debilis debilis</i>	1	Yes	7
<i>Carex eburnea</i>	–	Yes	2
<i>Carex hitchcockiana</i> ^A	–	–	–
<i>Carex interior</i>	2	–	–
<i>Carex muhlenbergii</i>	1	–	–
<i>Carex oligocarpa</i>	1	–	–
<i>Carex prairea</i> ^A	–	–	–
<i>Carex retroflexa</i>	2	Yes	4
<i>Carex shortiana</i> ^A	–	–	–
<i>Carex stricta</i>	1	Yes	1
<i>Carex utriculata</i>	1	–	–
<i>Castanea dentata</i>	19	Yes	9
<i>Castilleja coccinea</i>	–	Yes	1
<i>Ceanothus americanus</i> ^A	–	–	–
<i>Celastrus scandens</i>	–	Yes	1
<i>Chaerophyllum procumbens</i>	–	Yes	1
<i>Chamaelirium luteum</i>	2	Yes	8
<i>Chimaphilla umbellata</i>	1	–	–
<i>Chrysogonum virginianum</i>	1	–	–
<i>Circaea alpina</i>	2	Yes	1
<i>Clintonia umbellulata</i>	1	–	–
<i>Coleataenia anceps</i>	4	Yes	1
<i>Collinsia verna</i> ^A	–	–	–
<i>Corallorhiza maculata</i>	48	Yes	1
<i>Corallorhiza odontorhiza</i>	1	Yes	3
<i>Cornus rugosa</i>	5	Yes	1
<i>Cynoglossum virginianum</i> var. <i>virginianum</i>	1	Yes	10

Table D-1 (continued). Rare plant occurrences in 2021. One occurrence is defined as one location or polygon regardless of number of individuals found at that location. A superscript “A” indicates species of interest neither recorded historically nor found in 2021 survey.

Scientific Name	Historic Record?	Found in 2021?	Total 2021 Occurrences
<i>Cypripedium acaule</i>	7	–	–
<i>Cypripedium calceolus</i>	12	–	–
<i>Cypripedium candidum</i>	2	–	–
<i>Cypripedium parviflorum</i> var. <i>pubescens</i>	11	Yes	1
<i>Dactylorhiza viridis</i>	1	–	–
<i>Deschampsia flexuosa</i>	3	–	–
<i>Desmodium rotundifolium</i>	–	Yes	6
<i>Diarrhena americana</i>	1	Yes	18
<i>Diarrhena obovata</i>	1	Yes	27
<i>Dichantherium acuminatum</i> ssp. <i>columbianum</i> ^A	–	–	–
<i>Dichantherium commutatum</i> ^A	–	–	–
<i>Dichantherium depauperatum</i>	2	–	–
<i>Dichantherium latifolium</i>	4	Yes	31
<i>Dichantherium sphaerocarpon</i> ^A	–	–	–
<i>Digitaria cognata</i>	1	–	–
<i>Doellingeria infirma</i>	4	Yes	1
<i>Dryopteris clintoniana</i> ^A	–	–	–
<i>Eleocharis elliptica</i>	–	Yes	2
<i>Elymus trachycaulus</i> (<i>Agropyron trachycaulum</i>)	3	–	–
<i>Enchylum bachmanianum</i>	2	–	–
<i>Endodeca serpentaria</i>	–	Yes	1
<i>Equisetum variegatum</i>	5	–	–
<i>Eupatorium sessilifolium</i>	3	Yes	1
<i>Euphorbia corollata</i>	4	Yes	3
<i>Euphorbia dentata</i>	–	Yes	2
<i>Frasera caroliniensis</i>	–	Yes	4
<i>Galearis spectabilis</i> (syn. <i>Orchis spectabilis</i>)	4	Yes	24
<i>Gentiana clausa</i>	19	Yes	5

Table D-1 (continued). Rare plant occurrences in 2021. One occurrence is defined as one location or polygon regardless of number of individuals found at that location. A superscript “A” indicates species of interest neither recorded historically nor found in 2021 survey.

Scientific Name	Historic Record?	Found in 2021?	Total 2021 Occurrences
<i>Gentianella quinquefolia</i>	1	–	–
<i>Gentianopsis crinita</i>	42	Yes	8
<i>Glyceria canadensis</i> ^A	–	–	–
<i>Glyceria melicaria</i>	1	–	–
<i>Goodyera pubescens</i>	5	Yes	10
<i>Helianthus microcephalus</i>	1	Yes	1
<i>Hepatica americana</i>	–	Yes	51
<i>Houstonia canadensis</i>	3	–	–
<i>Hydrocotyle americana</i>	2	Yes	7
<i>Hypericum ascyon (pyramidatum)</i>	1	–	–
<i>Hypericum majus</i>	1	–	–
<i>Iris cristata</i>	3	Yes	1
<i>Iris versicolor</i> ^A	–	–	–
<i>Isotria verticillata</i>	3	–	–
<i>Juglans cinerea</i>	25	Yes	9
<i>Juncus greenei</i>	1	–	–
<i>Juniperus communis</i>	28	Yes	20
<i>Lactuca floridana</i> ^A	–	–	–
<i>Lechea intermedia</i>	9	Yes	1
<i>Lespedeza frutescens</i>	2	Yes	12
<i>Lespedeza hirta</i>	4	Yes	8
<i>Lespedeza procumbens</i>	–	Yes	1
<i>Liatris aspera</i> ^A	–	–	–
<i>Linum striatum</i>	1	Yes	1
<i>Linum virginianum</i>	1	Yes	3
<i>Liparis lilifolia</i> ^A	–	–	–
<i>Liparis loeselii</i>	2	–	–
<i>Lobelia spicata</i>	–	Yes	5

Table D-1 (continued). Rare plant occurrences in 2021. One occurrence is defined as one location or polygon regardless of number of individuals found at that location. A superscript “A” indicates species of interest neither recorded historically nor found in 2021 survey.

Scientific Name	Historic Record?	Found in 2021?	Total 2021 Occurrences
<i>Lonicera canadensis</i>	2	–	–
<i>Lupinus perennis</i> ^A	–	–	–
<i>Maianthemum stellatum</i>	–	Yes	1
<i>Melanthium virginicum</i>	2	–	–
<i>Moehringia lateriflora</i>	2	Yes	1
<i>Monotropa hypopitys</i>	8	Yes	16
<i>Morella pensylvanica</i>	–	Yes	1
<i>Morus rubra</i>	4	–	–
<i>Muhlenbergia sobolifera</i>	5	–	–
<i>Myosotis verna</i> ^A	–	–	–
<i>Nabalus albus</i> ^A	–	–	–
<i>Orobanche uniflora</i>	12	–	–
<i>Orthilia secunda</i>	2	–	–
<i>Oryzopsis asperifolia</i>	34	–	–
<i>Oxalis grandis</i>	1	Yes	4
<i>Oxalis violacea</i>	12	Yes	7
<i>Panax quinquefolius</i>	10	Yes	12
<i>Parnassia glauca</i> ^A	–	–	–
<i>Pedicularis lanceolata</i>	1	Yes	12
<i>Penstemon hirsutus</i>	–	Yes	1
<i>Phlox maculata</i> ^A	–	–	–
<i>Phlox pilosa</i>	–	Yes	1
<i>Phlox subulata</i> ^A	–	–	–
<i>Piptatherum racemosum</i>	2	–	–
<i>Platanthera lacera</i>	–	Yes	1
<i>Platanthera orbiculata</i>	32	Yes	4
<i>Poa languida</i>	7	–	–
<i>Poa palustris</i>	2	Yes	1

Table D-1 (continued). Rare plant occurrences in 2021. One occurrence is defined as one location or polygon regardless of number of individuals found at that location. A superscript “A” indicates species of interest neither recorded historically nor found in 2021 survey.

Scientific Name	Historic Record?	Found in 2021?	Total 2021 Occurrences
<i>Polygala senega</i>	1	–	–
<i>Potamogeton natans</i>	3	–	–
<i>Prenanthes crepidinea</i>	1	Yes	1
<i>Prunus americana</i>	2	Yes	4
<i>Prunus pensylvanica</i> ^A	–	–	–
<i>Pycnanthemum muticum</i>	8	Yes	31
<i>Quercus imbricaria</i>	11	Yes	21
<i>Ranunculus fascicularis</i> ^A	–	–	–
<i>Rhamnus alnifolia</i>	–	Yes	2
<i>Rhexia virginica</i>	2	–	–
<i>Rhus aromatica</i> var. <i>aromatica</i>	1	Yes	2
<i>Salix humilis</i>	–	Yes	1
<i>Schoenoplectus americanus</i> ^A	–	–	–
<i>Sericocarpus asteroides</i>	3	Yes	1
<i>Shepherdia canadensis</i>	13	Yes	1
<i>Silphium laciniatum</i>	2	Yes	1
<i>Solidago squarrosa</i>	10	–	–
<i>Solidago ulmifolia</i>	1	Yes	2
<i>Sphenopholis pensylvanica</i>	2	–	–
<i>Spiranthes cernua</i>	–	Yes	2
<i>Spiranthes lacera</i>	–	Yes	2
<i>Spiranthes lucida</i>	10	–	–
<i>Spiranthes magnicamporum</i>	28	Yes	27
<i>Spiranthes ovalis</i>	16	Yes	8
<i>Spiranthes tuberosa</i>	1	–	–
<i>Sporobolus michauxianus</i> ^A	–	–	–
<i>Symphoricarpos orbiculatus</i>	3	Yes	46
<i>Symphyotrichum oolentangiense</i>	–	Yes	5

Table D-1 (continued). Rare plant occurrences in 2021. One occurrence is defined as one location or polygon regardless of number of individuals found at that location. A superscript “A” indicates species of interest neither recorded historically nor found in 2021 survey.

Scientific Name	Historic Record?	Found in 2021?	Total 2021 Occurrences
<i>Taxus canadensis</i>	7	Yes	1
<i>Tipularia discolor</i>	–	Yes	1
<i>Triglochin maritima</i>	1	–	–
<i>Valerianella chenopodiifolia</i>	–	Yes	3
<i>Vicia americana</i>	1	Yes	2
<i>Vicia caroliniana</i>	–	Yes	2
<i>Viola palmata</i>	5	Yes	21
<i>Viola sagittata</i> var. <i>ovata</i>	2	Yes	1
<i>Vitis vulpina</i>	1	Yes	12
<i>Waldsteinia fragarioides</i>	9	Yes	4
<i>Zizania aquatica</i>	2	Yes	5
<i>Zizania palustris</i> ^A	–	–	–

Table D-2. Additional 2021 rare plant occurrences not on the list.

Scientific Name	Found in 2021?	Total 2021 Occurrences	Management Zones
<i>Morella pensylvanica</i>	Yes	1	Stanford Run /Hines Hill High Value Experience Zone
<i>Platanthera lacera</i>	Yes	1	Virginia Kendall High Value Experience Zone
<i>Spiranthes cernua</i>	Yes	2	Stanford Run /Hines Hill High Value Experience Zone (1); A-P North Sensitive Resources Zone (1)
<i>Tipularia discolor</i>	Yes	1	Virginia Kendall High Value Experience Zone

Appendix E. Species commentary

Species-by-species commentary: discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. Note that the sample sizes of species records are too small to draw statistically significant conclusions. Any correlations in this table, explicit or implied, are anecdotal. We hope they prove useful, but they should be taken with a grain of salt, and any management decisions based on them should be also informed by the best professional judgement of experienced land managers and biologists.

Table E-1. Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Acer spicatum</i>	March–May	0	1	No historic records. One new record in 2021, on a steep, north-facing slope in Bedford Reservation, in the Tinker’s Creek gorge growing below rock outcrops. This species is relatively easy to identify and can be ID’d at any time in growing season, so occurrences were not likely missed during surveys.	Mixed and coniferous forests and thickets, including deciduous forests and forested bluffs or banks, conifer swamps; sometimes growing with <i>A. pensylvanicum</i> but usually in somewhat moister forests.	n/a
<i>Alopecurus aequalis</i>	June–July	0	0	No historic records; no new records in 2021. Flowers/fruit required for ID. Inconspicuous species, easy to overlook. Additional occurrences could have been missed due to survey timing.	In shallow water and wet places: shores, ponds, ditches, marshes, moist depressions and wet meadows, stream margins, swamps and bogs, sometimes also in very calcareous places.	n/a
<i>Anaphalis margaritacea</i>	July–October	0	1	One record from the 2021 survey for a potential occurrence of this species. Listed as extirpated in Ohio, this species has a history of misidentification problems. Record should be revisited and verified in the future. Non-flowering plants are inconspicuous. Late-season bloomer; could have been missed on early-season transects.	Often in somewhat disturbed areas. Usually in dry sandy or rocky open places such as shores, dunes, fields, roadsides and railroads; in dry savannas of aspens or mixed conifers and hardwoods, especially along borders and in clearings (following logging or fire) and on trails.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Arabis canadensis</i>	May–July	0	0	None found. Narrow survey window (May–July), could have been missed either early or late in the season.	Dry forests, especially oak-hickory, banks, and bluffs; forested dunes.	n/a
<i>Arabis hirsuta</i> var. <i>adpressipilis</i>	March–June	0	0	None found. Narrow survey window (March–June), could have been missed in mid-season or late-season surveys.	Ravines, pastures, cliffs, calcareous talus, dolomite glades, rich woods, bluffs, rocky ledges	n/a
<i>Aralia spinosa</i>	July–August (June–September)	1	0	One historic record; not found in 1986; not found in 2021. This is a conspicuous species, easy to spot and ID at any time of year. Sometimes used in landscaping, so historical records could have been introduced. It may even have been intentionally eradicated, as <i>Aralia spinosa</i> is considered non-native to northern Ohio and can occasionally spread aggressively.	Open forests, forest edges, and bluffs	In thickets, young forests and roadside margins. <i>Aralia spinosa</i> is considered native to southern Ohio. Populations elsewhere are thought to be escapes from cultivation. Species associates include <i>Pinus virginiana</i> , <i>Tsuga canadensis</i> , <i>Sassafras alba</i> .
<i>Asclepias exaltata</i>	May–August	0	0	None found in 2021. Not documented historically.	Only true forest understory species [of <i>Asclepias</i>]. Usually in dry rocky forests and savannas with oaks and other trees such as hickory, pine, and aspen; banks and borders, even roadsides; much less often in rich beech-maple forests or swamps.	n/a
<i>Asclepias quadrifolia</i>	May–July	0	1	No historic records; one new record in 2021. Growing on a slope on the northeastern side of Stumpy Basin.	Dry, rocky, open woods, often on slopes and ridges.	n/a
<i>Asclepias tuberosa</i>	June–August	0	1	No historic records; one new record in 2021. Growing on a slope on the northeastern side of Stumpy Basin.	Dry barrens and savannas with oak, sassafras, and/or pines, including jack pine plains; sandy roadsides and fields.	n/a
<i>Asplenium trichomanes</i>	–	2	0	2 historic records, none found in 2021	Rock outcrops, talus boulders, crevices in limestone pavement, in shade or partial shade.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Aureolaria virginica</i>	June–August	1	3	1 historic record; 3 found in 2021. The historic record was not re-located, but it was revisited in September when it would not have been in bloom. New records were found in dry-mesic oak forest, consistent with MI Flora habitat description.	Oak openings, sandy oak and oak-hickory savanna, with jack pine and aspen often present, forest borders and clearings.	n/a
<i>Baptisia tinctoria</i>	May (south)–Sept (north)	4	0	4 historic records, none found in 2021. One record was revisited in early August, when it would have been easily recognizable. The other records were not revisited because they are outside priority survey areas and not near transects.	Open forests (oak hickory), sandy openings and borders, fencerows.	n/a
<i>Betula populifolia</i>	April	2	8	2 historic records; 8 found in 2021. Some observations have low confidence; can hybridize with <i>Betula pendula</i> , and flowers/fruit are required to distinguish the pure species from hybrids. Records should be revisited and flowers/fruit collected.	Moist to sandy open fields, forest edges, and edges of peatlands, in acid soils.	n/a
<i>Bromus nottowayanus</i>	July–August	10	54	10 historic records; 54 records found in 2021. Found mostly in forest types: cottonwood-sycamore floodplain, dry-mesic oak, successional mixed hardwood, successional floodplain hardwood, and beech-maple glaciated. Most records were in floodplains or on lower slopes near smaller streams.	Rich hardwood forests, usually near streams but often above the lowest, wettest river bottoms; occasionally in drier forests on banks and slopes.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Buxbaumia aphylla</i>	May–July	3	0	3 historic records, none found in 2021. The size, shape, growth habit, and overall search image for a moss is quite different from the vascular plants on the survey list. It would have been extremely easy to overlook while also searching for the other species on the list. If this species is of interest, recommend targeted surveys for this species alone, or for similarly diminutive species such as lichens or other mosses.	Pioneer on disturbed sandy or clayey soil; decaying wood, humus, shallow acid soil, and soil depressions on rock outcrops.	n/a
<i>Calystegia spithamea</i>	late spring to midsummer	0	2	No historic records, two found in 2021. Both new records found on steep slopes under oak-dominated canopy.	Dry sandy or rocky ground, especially in aspen, oak, and/or jack pine savanna, often with bracken. Does well after fire, and is often found on banks, in clearings, or on bluffs where there is some disturbance.	n/a
<i>Canoparmelia caroliniana</i>	–	0	0	No historic records; none found in 2021. Comments for the moss, <i>Buxbaumia aphylla</i> , also apply to this lichen.	Common in southeastern US on conifers and other acidic bark trees, more rarely on rocks; found in two Ohio counties.	n/a
<i>Capnoides sempervirens</i>	May–Sept. Germinated seeds may emerge later same year.	1	0	1 historic record; none found in 2021. Short-lived, disturbance-loving species. The historic record may be dormant in the seed bank if disturbances in the area have been removed, or it may have been not blooming at time of survey. Conversely, Andreas speculated that it may have been impacted by “overshading by closing in of the once-cleared canopy as well as excess use of the right-of-way by visitors.”	Rock ledges/summits, gravelly shores, piney savanna, but more often 1–2 years after disturbance along roadsides, clearings, trails, gravel or sand pits, etc., dying out after about another 2 years if conditions are stable.	Frequently grows on rocky, shaded or semi-shaded cliffs. Habitat affinities include <i>Agrostis</i> sp, <i>Carex pensylvanica</i> , <i>Carex</i> sp, <i>Tsuga canadensis</i> , <i>Viola pubescens</i> and <i>Gaultheria procumbens</i> . Potential habitat for this species occurs on rock outcrops throughout the CVNRA, but this location and others were not found during the 1985 and 1986 collecting seasons.

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Carex aggregata</i>	late spring to mid summer	1	0	Recorded in 1986 Andreas report; none found in 2021. Inflorescence or fruit necessary for ID. Limited survey window, unidentifiable once perigynia fall off. Historically recorded populations may have been impacted by increased canopy cover or changes in wetland hydrology.	Roadsides and lawns; floodplain forests, woodland openings, wooded slopes and ravines, moist meadows in wooded areas, and edges of streams in partially shaded areas.	Found in open to semi-shaded moist areas such as fields, thickets, trail margins, open young forests and floodplains. Species associates include <i>Carex hirsutella</i> , <i>Carex rosea</i> , <i>Sanicula gregaria</i> , <i>Panicum lanuginosum</i> , <i>Panicum</i> sp, <i>Impatiens capensis</i> , <i>Equisetum hyemale</i> , and <i>Solidago canadensis</i> . Potential habitat occurs for this species throughout the CVNRA and additional locations are expected to be found.
<i>Carex annectens</i>	June–August	1	7	1 historic record; 7 records in 2021. This species may be easily overlooked due to its similarity to the very common <i>C. vulpinoidea</i> . Several populations from 2021 were interspersed with larger populations of <i>C. vulpinoidea</i> . Inflorescence or fruit necessary for ID.	Moist to dry meadows and prairies, relatively uncommon.	(<i>Carex annectens</i> var <i>xanthocarpa</i> in Andreas report) occurs on moist open areas including seeps, meadows, roadside ditches and marshes. Species associates include <i>Scirpus pendulus</i> , <i>Anemone virginiana</i> and <i>Corylus americana</i> . This species closely resembles the typical variety, <i>Carex annectens</i> var. <i>annectens</i> , which also occurs in the CVNRA and distinguishing between the two species in the field is difficult. This species may be more common in the CVNRA than records indicate.
<i>Carex arctata</i>	June–July	4	0	4 historic records; none found in 2021. Inflorescence or fruit necessary for ID. Limited survey window, unidentifiable once perigynia fall off. Andreas said, “since this species is listed as endangered in Ohio, monitoring population conditions on a five-year cycle is recommended.” (<i>C. arctata</i> has since been downlisted to “threatened”.)	Rich deciduous and beech-maple-hemlock forests, including forested dunes; also in rocky open forests, mixed forests, and under conifers, particularly on moist ground.	Occurs on moist rock outcrops and rocky slopes in hemlock-beech and beech forests. Associate species include <i>Poa alsodes</i> , <i>Panicum columbianum</i> , <i>Pyrus melanocarpa</i> , <i>Maianthemum canadense</i> and <i>Polypodium virginianum</i> . Potential habitat for this species occurs on shaded rock outcrops elsewhere in the CVNRA. Similar areas were investigated but no new populations were located.

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Carex argyrantha</i>	June–August	16	5	16 historic records; 5 records found in 2021. All records found were in Ritchie Ledges UHA. Historic records not re-located were revisited too late in the season. As with most sedges, <i>C. argyrantha</i> can only be identified during the narrow window when it has mature inflorescences or fruit.	Sandy forests, especially along roads and clearings; thickets; forested dunes and less often in richer deciduous forests, quite local and often appearing after disturbance.	Occurs on thin soils in dense shaded or semi-shaded areas on rock outcrops and rock ledges. Elsewhere in Ohio, habitat includes oak woods, aspen thickets, trains, clearings. Species associates include <i>Quercus alba</i> , <i>Chimaphila umbellata</i> , <i>Vaccinium vacillans</i> , <i>Carex pensylvanica</i> , <i>Carex umbellata</i> , <i>Panicum columbianum</i> and <i>Gaylussacia baccata</i> . Habitat for this species occurs on shaded rock outcrops elsewhere in the CVNRA. Similar areas were investigated but no new populations were located.
<i>Carex atlantica</i>	mid May–late June	3	0	Three historic records, only one of which was relocated in 1986; none found in 2021. Inflorescence or fruit necessary for ID. Limited survey window, unidentifiable once perigynia fall off. The population located in 1986 in Stumpy Basin had an impressive 100+ plants and might be possible to relocate if revisited during the flowering period (mid May–late June).	Swamps, both coniferous and deciduous, in acid soils; sphagnum bogs.	Occurs in a cattail marsh and sedge meadow. Elsewhere in Ohio it is found associated with moderately minerotrophic peatlands (fens), sedge meadows and wet woods. Species associates include <i>Gentiana crinita</i> , <i>Carex interior</i> , <i>Typha latifolia</i> and <i>Salix</i> sp. Suitable habitat for this species occurs on calcareous hillside seeps and alluvium throughout the CVNRA.
<i>Carex aurea</i>	June–August	17	2	17 historic records; 2 records found in 2021. All records found were in Stumpy Basin. Most historic records not re-located were revisited too late in the season. As with most sedges, <i>C. aurea</i> can only be identified during the narrow window when it has mature inflorescences or fruit. While this species has very distinctive perigynia, it is rather diminutive and can therefore be easily overlooked, especially if growing among taller vegetation.	In almost all kinds of moist, open ground, as well as fens, cedar or tamarack swamps, and moist forests and thickets.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Carex bebbii</i>	June–July	8	0	Eight historic records; none found in 2021. Inflorescence or fruit necessary for ID. Limited survey window, unidentifiable once perigynia fall off. Section Ovales sedges are particularly difficult to key. The site of the Deep Lock Quarry record was revisited later in the growing season, when most sedges were losing their perigynia or had already senesced.	Wet sandy shores, meadows, swales, ditches, stream banks, cedar and tamarack swamps, moist forests, usually in open ground or clearings.	Occurs in calcareous soils such as seeps, fens and thickets. Associate species include <i>Alnus rugosa</i> , <i>Juncus effusus</i> , <i>Thelypteris palustris</i> , <i>Glyceria striata</i> , <i>Juncus marginalis</i> and <i>Carex</i> sp. Potential habitat occurs for this species in open calcareous seeps throughout the CVNRA yet more localities could not be located.
<i>Carex cephaloidea</i>	June–July	3	9	Three historic records; nine found in 2021. All but two records were in the month of June; one collected in July was noted as “past peak.” Historic records were either not revisited or revisited too late in the season. Populations found in 2021 are new records. Scattered throughout park. Habitats consistent with MI Flora and Andreas.	Rich deciduous forests, stream banks, thickets, less often in meadows (see comments under <i>C. cephalophora</i>).	Found in shaded mesic and hemlock-beech woods. Elsewhere in Ohio it has been reported from tickets and floodplains. Species associates include <i>Fagus grandifolia</i> , <i>Tsuga canadensis</i> , <i>Viburnum acerifolium</i> , and <i>Dryopteris marginalis</i> . Although potential habitat occurs for this species throughout the CVNRA, additional populations were not located during the 1985 and 1986 field season.
<i>Carex crawei</i>	June–August	4	0	Four historic records; none found in 2021. Inflorescence or fruit necessary for ID. Limited survey window, unidentifiable once perigynia fall off.	Sandy or gravelly hummocks and ridges (often at the edge of cedar), wet marly sands and beach pools, and limestone pavements near the shores of the Great Lakes; inland very locally in fens, calcareous cedar thickets, limestone ledges, and wet prairies, often associated with lakes and rivers.	Occurs in calcareous alluvium. Elsewhere in Ohio it occurs in wet sedge meadows and fens. Species associates include <i>Carex interior</i> , <i>Carex atlantica</i> , <i>Physocarpus opulifolia</i> , <i>Liparis loeselii</i> and <i>Rosa palustris</i> . Suitable habitat occurs in moist calcareous seeps throughout the CVNRA. Additional records will likely be located.

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Carex debilis debilis</i>	June–August	1	7	1 historic record; 7 new records in 2021. Historic record not relocated, but it's off-transect and nearby transects were visited in May, probably too early for this species. New records were found in hardwood forests, on slopes, ridgetops and flatlands. Two populations near the Oak Grove Picnic Area in Brecksville Reservation consisted of many hundreds of individuals.	Moist ground of all sorts, open or (usually) more or less forested (hardwoods rather than conifers); mostly in acidic, sandy soils.	n/a
<i>Carex eburnea</i>	May–July	0	2	2 records in 2021, both in Stumpy Basin.	Usually under cedar (also fir, jack pine, and white spruce) on moist sandy or calcareous gravelly soil near the shores of Lake Michigan and Lake Huron; also inland in moist cedar thickets, on logs in wet conifer swamps, and marly, clay, or rocky bluffs and banks.	n/a
<i>Carex hitchcockiana</i>	June–August	0	0	Late-flowering sedge. Inflorescence or fruit necessary for ID. Limited survey window, unidentifiable once perigynia fall off.	Rich deciduous forests (beech-maple and alluvial forests); rather local	n/a
<i>Carex interior</i>	June–July	2	0	2 historic records; not found in 2021. Inflorescence or fruit necessary for ID. Limited survey window, unidentifiable once perigynia fall off.	Widespread in wet places, especially fens and cedar (or spruce and tamarack) swamps; also on shores, in open meadows, and along streams; usually in calcareous soils.	Occurs at the edge of a cattail marsh and a sedge meadow on alluvium. Elsewhere in Ohio it is found associated with moderately minerotrophic peatlands (fens), sedge meadows and wet woods. Species associates include <i>Gentiana crinita</i> , <i>Carex crawei</i> , <i>Carex atlantica</i> , <i>Typha latifolia</i> and <i>Salix</i> sp. Suitable habitat for this species occurs on calcareous hillside seeps and alluvium throughout the CVNRA. Additional records will likely be located.

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Carex muehlenbergii</i>	June–July	1	0	One historic record, none found in 2021. Inflorescence or fruit necessary for ID. Limited survey window, unidentifiable once perigynia fall off.	Dry sandy fields, banks, and borders of forests; dunes; oak and aspen forests.	<i>Carex muhlenbergii</i> occurs within the CVNRA in dry oak woods. Associate species include <i>Carex rosea</i> , <i>Panicum sphaerocarpon</i> , <i>Panicum lanuginosum</i> , <i>Sanicula gregaria</i> , <i>Galium tinctorium</i> and <i>Mitchella repens</i> . Potential habitat occurs throughout the CVNRA and more populations are likely to be found.
<i>Carex oligocarpa</i>	June–July	1	0	One historic record, none found in 2021. Inflorescence or fruit necessary for ID. Limited survey window, unidentifiable once perigynia fall off.	Rich, though sometimes dry, deciduous forests	n/a
<i>Carex prairea</i>	June–July	0	0	Inflorescence or fruit necessary for ID. Limited survey window, unidentifiable once perigynia fall off.	Calcareous wet sedge meadows, swales, fens, marshy shores, tamarack and cedar swamps, and stream banks.	n/a
<i>Carex retroflexa</i>	May–July	2	4	Inflorescence or fruit necessary for ID. Limited survey window, unidentifiable once perigynia fall off. All 2021 records for this species were marked as low confidence and are likely misidentified <i>Carex rosea</i> .	Fields and open young forests in disturbed or successional habitats	n/a
<i>Carex shortiana</i>	May–July	0	0	No historic records; none found in 2021. Inflorescence or fruit necessary for ID. Limited survey window, unidentifiable once perigynia fall off.	Openings in moist deciduous woodlands, woodland borders, moist prairies (particularly along rivers), sedge meadows, seeps and fens, low lying areas along rivers and ponds, powerline clearances in wooded areas, abandoned fields, and ditches.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Carex stricta</i>	May–June (June)	1	1	The 2021 record for this species was found in a groundwater-influenced wetland along Yellow Creek, where it was locally dominant. This species generally grows in large, tussock-forming populations which make it relatively conspicuous, and it can be identified vegetatively.	Wet, usually open ground: fens, marshes, meadows (often springy), edges of lakes and streams, margins of bogs, and cedar or tamarack swamps (especially in clearings); often in large, tall clumps (tussocks), but sometimes forming more uniform swards.	n/a
<i>Carex umbellata</i>	May–June	0	0	No historic records; none found in 2021. Early flowering sedge (early April to May). Inflorescence or fruit necessary for ID. Limited survey window, unidentifiable once perigynia fall off. This species would not have been identifiable when most of the transects were surveyed.	Sandy or gravelly ground, rock crevices, moist banks and sandy excavations; gravelly shores, open, dry forests, and coniferous thickets especially near the Great Lakes. More of a calciphile than the very similar <i>Carex tonsa</i> .	Occurs in dry, sandy thin soils in somewhat disturbed areas. Species associates include <i>Quercus alba</i> , <i>Lechea</i> sp, <i>Panicum</i> sp, and <i>Tsuga canadensis</i> . Potential habitat occurs for this species throughout dry open woods and semi-shaded slumps in the CVNRA and additional locations are expected to be found.
<i>Carex utriculata</i>	June–August	1	0	Inflorescence or fruit necessary for ID. Limited survey window, unidentifiable once perigynia fall off.	Very wet muddy or sandy places: marshy stream margins, lake shores, river banks; swamps, marshes, ponds, ditches, and bogs.	n/a
<i>Castanea dentata</i>	–	19	9	19 historic records; 9 found in 2021. One historic record relocated; eight new records. Six historic records were not revisited because they were off-transect and outside priority areas. Non-native chestnut trees are fairly common on old homestead sites in the park; these can often be recognized before examining any botanical characters, purely by the fact that they were generally planted in pairs, one male and one female tree, to ensure nut production.	Dry forests	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Castilleja coccinea</i>	May–August	0	1	No historic records; 1 new record in 2021. On steep slope, dominated by <i>Liriodendron tulipifera</i> , above Stumpy Basin.	Calcareous sandy or gravelly shores, including interdunal flats and conifer thickets; river and stream banks, swamps (especially cedar), occasionally fens; marshy ground, meadows, springy and marly places, crevices and shallow soil at limestone outcrops; moist jack pine and oak scrub.	n/a
<i>Ceanothus americanus</i>	early to mid summer	0	0	No historic records; no new records in 2021.	Dry open sandy plains and prairie-like areas (spreading to roadsides), dry savannas (with oak, aspen, and pine); often in openings or transitional areas between lakes or marshes and forests; river banks.	n/a
<i>Celastrus scandens</i>	May–June	0	1	1 record found in 2021. Flowers or fruit are required to distinguish this species from the very common invasive species <i>C. orbiculatus</i> . However, immature or shade-grown individuals may not flower in a given year.	Shores and dune thickets, stream and river banks, roadsides and fencerows, rock outcrops and talus slopes, dry to moist forests and well as open ground.	n/a
<i>Chaerophyllum procumbens</i>	Blooms in late April or early May, and withers to the ground by the end of June.	0	1	1 new record found in 2021. This record was found in early June, and the botanist noted that the petals were gone and the flowers past prime. This plant is known to senesce after blooming, so there could be additional populations that were missed due to survey timing. Further surveys for this species should be conducted in late April and early May.	Rich forests, especially on floodplains.	n/a
<i>Chamaelirium luteum</i>	May–June (March–June)	2	8	2 historic records; 8 found in 2021. The 2021 records were found in beech-maple glaciated and dry-mesic oak forests in the Blossom Woods NZ.	Open woodlands	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Chimaphilla umbellata</i>	mid to late summer	1	0	1 historic record; not found in 2021. Andreas report noted that, “this species grows in an area in the park [Virginia Kendall] with high visitor use. Rock climbing, trampling and compaction of the soil are all present threats to this area.” As this is a distinctive species, easy to spot and identify throughout the growing season, it seems likely that the historic record has been lost.	Dry to boggy forests, especially with pine and oak, persisting after some disturbance; dry, rocky openings and thickets.	This species occurs in dry, sandy acidic soils and sandstone outcrops. Species associates include <i>Tsuga canadensis</i> , <i>Fagus grandifolia</i> , <i>Quercus alba</i> , <i>Carex</i> sp and <i>Vaccinium vacillans</i> . Habitat for this species occurs throughout the CVNRA. Many of these areas have been visited, and no new locations have been found.
<i>Chrysogonum virginianum</i>	May–October	1	0	1 historic record; not found in 2021. Andreas (1986) also did not re-locate this record and speculated that the historic record may have been from a garden.	Woodland areas.	Habitat affinities: Unknown. This species occurs in Southern Ohio. It is occasionally sold in the nursery trade and this record may be from a garden. Unsuccessful attempts were made during the 1985 and 1986 field seasons to re-locate this taxon.
<i>Circaea alpina</i>	June–August	2	1	2 historic records; 1 found in 2021. One historic record was revisited but not found; the other is off-site and was not revisited. The 2021 record is new, from an eroding cliffside in Bedford Reservation, in a hemlock-dominated portion of a beech-maple forest. This species is similar to the very common <i>C. canadensis</i> , especially when immature, and therefore additional populations may have been overlooked.	Swamps (especially cedar), frequently on rotting logs; hardwood forests, especially in moist depressions, ravines, and springy slopes.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Clintonia umbellulata</i>	May–June	1	0	1 historic record; not found in 2021. The historic record is marked, “Not found since 1995.” It was revisited on a meander survey in early September when this species would not have been in bloom. <i>Clintonia umbellulata</i> is Endangered in Ohio. This record should be revisited in May–June. The habitat in the area is described as, “Mesic to dry forested slopes and low ridges; ravine floodplain including seeps.”	Cool, rich mountain woods; dry ridges and slopes	n/a
<i>Coleataenia anceps</i>	June–October	4	1	4 historic records; 1 found in 2021. One historic record was relocated. The other records are all in the same vicinity, and likely only represent two populations. The second population is between transects and was not revisited.	Low, moist areas. Moist, especially sandy soils.	n/a
<i>Collinsia verna</i>	mid to late spring	0	0	No historic records; no new records in 2021.	Rich deciduous forests, especially in ravines and moist areas.	n/a
<i>Corallorhiza maculata</i>	July–August (April–September)	48	1	48 historic records; one found in 2021. This is a saprophytic species which spends most of its life cycle underground, only emerging above ground to flower and fruit. It may be present but not visible aboveground in transects when they were surveyed.	In forests of all kinds; conifers, hardwoods, mixed; moist or dry; from sandy oak-hickory or red pine to wet cedar-hemlock; often common in pine and spruce forests on old dunes as well as in beech-maple stands.	This species occurs in shaded to semi-shaded open woods, including mature oak woods, beech-maple woods and secondary-growth red maple woods. Species associates include <i>Acer rubrum</i> , <i>Quercus alba</i> , <i>Swertia caroliniensis</i> and <i>Fagus grandifolia</i> . Habitat is available for this species throughout the CVNRA. Additional locations are expected to be found. This orchid may live for years underground as a saprophyte. This species may be more common than records indicate.

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Corallorhiza odontorhiza</i>	August– September	1	3	1 historic record; 3 found in 2021. The historic record was relocated, and 10 additional plants were found at a second location (recorded as two separate records, about 30 meters apart). The new records are in dry-mesic oak forest in Blossom Woods Natural Zone, near the East Rim Trail. The field botanist noted, “hundreds of plants. anthropogenic trails everywhere, population clearly being trampled by wild flower viewers.” Steps should be taken to protect these populations from trampling. Since this population is already known to wildflower viewers, it may be advisable to establish one trail that allows park users to view the flowers without stepping on them, along with fences, signs, and monitoring by park rangers during peak bloom.	Dry open oak forests; pine plantations; much less often beech-maple forests or under tamarack	n/a
<i>Cornus rugosa</i>	–	5	1	5 historic records; 1 found in 2021. Two of the historic records are from the same location; this record was re-confirmed. One historic record was revisited and not found. Two records fell between transects and were not revisited.	Deciduous and mixed forests, especially at borders near lakes, rivers, and clearings; also on rock outcrops and talus slopes; fencerows, forested bluffs.	n/a
<i>Cynoglossum virginianum</i> var. <i>virginianum</i>	May–June	1	10	1 historic record; 10 found in 2021. The historic record falls between transects, and was not revisited. The ten new records are all from the slopes above Stumpy Basin.	Dry woods, woodland edges, and slopes in shade or part shade.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Cypripedium acaule</i>	May–July	7	0	7 historic records; not found in 2021. The historic records were revisited in late August and early September, too late for this species. Since the historic records are relatively recent (1999–2005), it seems likely that they could be relocated with appropriately-timed (May–July) surveys.	Sandy, dry forests under red and jack pine, mixed oak and pine, or aspens; also in moist to wet ground, especially on hummocks in sphagnum bogs and under cedar, tamarack, or spruce in coniferous swamps, always in acidic soils.	n/a
<i>Cypripedium calceolus</i>	May–June	12	0	12 historic records; not found in 2021. This species is synonymous with <i>Cypripedium parviflorum</i> , though it’s unclear whether the historic records indicate <i>C. parviflorum</i> var. <i>pubescens</i> or <i>C. parviflorum</i> var. <i>parviflorum</i> .	In a great diversity of habitats except the driest: moist forests (coniferous, mixed, deciduous), fens, meadows, borders of forests and clearings, often under cedar, and mostly in clearly calcareous soils.	n/a
<i>Cypripedium candidum</i>	May–June	2	0	2 historic records; not found in 2021. The historic records were revisited in mid-summer, when this species would have been past peak bloom. The historic records appear to represent only one population.	In essentially full sun, in fens, wet, calcareous meadows, usually with tamarack and shrubby cinquefoil, wet prairies, rarely in slightly drier prairie habitats: very local.	n/a
<i>Cypripedium parviflorum</i> var. <i>pubescens</i>	May–July	11	1	11 historic records; one found in 2021. Blooms in early May to early June. Identifiable in vegetative state, but much more conspicuous with flowers. Young plants are cryptic, and may not produce above-ground parts for several years. Historic records not on transects were visited during meander surveys, but most meanders took place later in the season, when this species would not have been blooming. If this species is of particular concern, targeted surveys should be performed between early May and early June.	Shade, sun; moist rich woods, bogs, swamps	This orchid occurs on steep, shaded wooded slopes and stream terraces. Species associates include <i>Acer saccharum</i> , <i>Fagus grandifolia</i> , <i>Carex hirstuella</i> , <i>Carex pensylvanica</i> and <i>Carex blanda</i> . Habitat is available for this species on the steep ravine slopes throughout the CVNRA. Additional locations are expected to be found. This orchid may live for years underground as a saprophyte. This species may be more common than records indicate.

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Dactylorhiza viridis</i>	April–June	1	0	1 historic record; not found in 2021.	Beech-maple or hemlock-hardwood, particularly on sandy soils of forested dunes; sometimes coniferous forests or mixed oak (hickory).	n/a
<i>Deschampsia flexuosa</i>	July–September	3	0	3 historic records; not found in 2021. One record revisited in July; vicinity of other two records visited in May, July and September, but only got within about 50 meters of recorded locations. This species flowers from July–September. It may have been missed due to seasonality, or from not revisiting the actual location.	Open generally dry sandy or rocky shores, dunes, and plains, usually associated with pine, oak, and aspen.	n/a
<i>Desmodium rotundifolium</i>	July–September	0	6	No historic records; 6 found in 2021. All records from upper slope above Stumpy Basin. Reported habitats are <i>Quercus alba</i> and <i>Acer saccharinum</i> forest, on slumping soils, one from edge of small clearing.	Oak forests (sometimes with hickory or pine); dry thickets and openings	n/a
<i>Diarrhena americana</i>	June–July	1	18	1 historic record; 18 found in 2021. The historic record was revisited in August, but not relocated. The new records were all found in July and August, mostly in floodplain forest. Several large populations were growing at the toe of forested slopes, near the edge of wetland and/or floodplain, often on calcareous soils.	Rich, moist woods	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Diarrhena obovata</i>	June–October	1	27	1 historic record; 27 found in 2021. This species has similar habitat requirements to the closely related <i>D. americana</i> . Like <i>D. americana</i> , <i>D. obovata</i> was found mostly on floodplain forest, with two populations in drier habitats (dry-mesic oak and sugar maple-chinkapin oak forests). The large number of records found for these two species suggests that there are more populations yet to be found.	Rich woodlands, most common in prairie states	n/a
<i>Dichanthelium acuminatum</i> ssp. <i>columbianum</i>	July–October	1	0	1 historic record; not found in 2021. The area around the historic record was searched on a meander survey in late June, when this species would not have been in flower. The survey was timed to detect sedges and did succeed at finding a population of <i>Carex argyrantha</i> . Recommend a targeted, species-specific survey in July–August (<i>Dichanthelium</i> spp bloom twice, and MI Flora keys are based on characteristics of the early flowers and fruit.)	Dry sandy open ground, thickets, and forests (jack pine, oak, and/or aspen), dune ridges, pine forests, and less often on moist shores.	(<i>Panicum columbianum</i> in Andreas report) Dry, thin soils on the top of rock ledges and dry wooded ridges. Associated species include <i>Gaylussacia baccata</i> , <i>Carex pensylvanica</i> , <i>Carex umbellata</i> and <i>Danthonia spicata</i> .
<i>Dichanthelium commutatum</i>	summer	0	0	No historic records; no new records in 2021. See notes for other <i>Dichanthelium</i> sp.	Sandy open or somewhat forested ground.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Dichanthelium depauperatum</i>	summer	2	0	2 historic records; not found in 2021. One historic record falls outside the study area and was not revisited. The other historic record was revisited in September without being relocated, however, it may have been too late for fruit from the first flowering, and too early for the second flowering. Recommend revisiting both records (if accessible) in late July–early August when they are most likely to have the mature fruit necessary for identification.	Dry usually sandy or rocky open ground (rarely in moist places); jack pine, aspen, and oak forests; pine-covered dunes.	(<i>Panicum depauperatum</i> in Andreas report) This historical record was not observed during the 1985 or 1986 field seasons. Elsewhere in Ohio this species occurs in sandy, disturbed soils. Species associates for the CVNRA are unknown. Suitable habitat occurs throughout the CVNRA and modern populations of this species are expected to be located.
<i>Dichanthelium latifolium</i>	summer	4	31	4 historic records, 31 records found in 2021. This species occurs on ridgetops and upper slopes in dry oak forests throughout CUVA, with tens of individuals commonly being found at each occurrence.	Forests and thickets, sometimes along edges but mostly not a plant of open ground: in rich deciduous forests (beech-maple, etc.), oak or oak-hickory, aspen, or mixed forests; on forested dunes and bluffs and river banks.	n/a
<i>Dichanthelium sphaerocarpon</i>	summer	0	0	No historic records; no new records in 2021.	Dry open sandy ground, fields, and sandy forests.	n/a
<i>Digitaria cognata</i>	August– September	1	0	1 historic record; not found in 2021. The historic record was not on a transect, and not visited in a meander survey, therefore it would not be expected to be relocated in this survey.	Dry prairies, old fields, sandy open ground	Found in highly disturbed area along the canal. Other habitats in Ohio include roadsides, railroad cinders and parking lots. Associated species include <i>Kochia scoparia</i> , <i>Ambrosia artimisiifolia</i> , <i>Echinochloa crus-calli</i> , <i>Setaria</i> sp and <i>Polygonum</i> sp.
<i>Doellingeria infirma</i>	July– September	4	1	4 historic records; 1 record found in 2021. The 2021 record was found in a canopy gap of an oak-dominated ridgetop forest along Quick Road. This species can be overlooked due to its similarity to the much more abundant <i>D. umbellata</i> .	Oak-hickory woodlands	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Dryopteris clintoniana</i>	–	0	0	No historic records; no new records in 2021.	Moist to wet deciduous or mixed conifer-hardwood forests	n/a
<i>Dryopteris filix-mas</i>	–	0	0	No historic records; no new records in 2021.	Northern hardwood or mixed conifer-hardwood forests, usually over calcareous rock outcrops or talus; only rarely in forests lacking exposed bedrock. Occasionally in open areas in sites like crevices in calcareous bedrock and more or less open conifer stands on thin soil over limestone.	n/a
<i>Eleocharis elliptica</i>	July–September	0	2	No historic records; 2 new records. Both new records are in Stumpy Basin.	Wet, often marly ground: fens, beaches, stony and often marshy shores, interdunal pools and flats, sandy swales and ditches; occasionally in bogs and along trails in conifer swamps; sometimes in shallow water.	n/a
<i>Elymus trachycaulus</i>	July–August	3	0	3 historic records; not found in 1986; none found in 2021. Andreas commented that typical habitat for this species is not found in CUVA.	Most often in dry or rocky forests and savannas (oak, jack pine, hickory), sand barrens, shores, and dunes; also in fens and tamarack swamps; less common along roadsides and in other disturbed places.	(<i>Agropyron trachycaulum</i> in Andreas report) This species was collected once in the CVNRA on eroding calcareous soils that are maintained by frequent slumping. Elsewhere in Ohio this species is associated with calcareous fens and sedge meadows. Species associates include <i>Andropogon gerardi</i> , <i>A. scoparius</i> , <i>Solidago bicolor</i> and <i>S. squarrosa</i> . Suitable habitats for this species as it occurs in Ohio are not common in the CVNRA. No fen communities were located in the CVNRA and the sedge meadows examined did not turn up new localities for <i>Agropyron trachycaulum</i> . Additional locations would not expected to be located. [sic]
<i>Enchylium bachmanianum</i>	–	2	0	2 historic records; not found in 2021. See comments about surveying for lichens and mosses at <i>Buxbaumia aphylla</i> .	n/a	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Endodeca serpentaria</i>	May–July	0	1	No historic records; 1 found in 2021. Found in a meander survey in late September, while searching for <i>Corallorhiza</i> spp. Habitat: mature mesic forest, hill side slump prairies.	Oak-hickory or mesic deciduous forests, often along rivers	n/a
<i>Equisetum variegatum</i>	late summer	5	0	5 historic records; none found in 2021. Historic populations were revisited in July and late September, although identification of this species should not be particularly season-dependent.	Wet calcareous meadows both natural (wet shores, beaches, and interdunal settings) and artificial (borrow pits, roadside banks, and ditches).	This species generally occurs on calcareous seeps and alluvium. Elsewhere in Ohio it is found in fens. Species associates include rushes and sedges. Suitable habitat for this species occurs on calcareous seeps and alluvium throughout the CVNRA.
<i>Eupatorium sessilifolium</i>	July–August	3	1	3 historic records; one found in 2021. Several late-September meander surveys in the area around the record above Stumpy Basin did not relocate it, but they were late in the season and did not cover the entire area with suitable habitat, so they may have missed it. The other two historic records (same approximate location, probably actually only one population) in Bedford Reservation are off-property, but close to a transect that was surveyed in April, too early to locate this species. The 2021 record is a new population. Suitable habitat (dry, open oak forest) for this species exists throughout CUVA, and more populations may exist.	Oak forests, shaded thickets and gravelly banks.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Euphorbia corollata</i>	early summer to early autumn	4	3	4 historic records; 3 found in 2021. One historic record, near A-P and Bolanz Roads, was revisited in late September without finding it and the botanist noted that the habitat was degraded; this location is on the edge of an agricultural field. Two of the other records were revisited without success in late summer. Two new records were found on field edges near Kendall Lake, close to a historic record, although the original record was not re-located. This species can be easy to overlook if growing among dense vegetation in open fields; one of the new records was found only because the botanist was off-transect while searching for a way through a dense autumn olive thicket. Suitable habitat exists throughout the park, and new populations are expected to be found in future surveys.	Sandy, dry plains and savanna (oak, sassafras, jack pine); fields and prairies; railroads and other disturbed ground.	n/a
<i>Euphorbia dentata</i>	July– September	0	2	No historic records; 2 found in 2021. One record found along Hike and Bike Trail, one along CVNP Scenic Railroad. Suitable habitat is common throughout the park, and additional surveys may find more populations.	Dry sandy soil, waste areas, agricultural margins; part shade or sun	n/a
<i>Frasera caroliniensis</i>	late spring to early summer	0	4	No historic records; 4 found in 2021. Records found May–July. Found in dry-mesic oak, successional hardwood, and beech-maple forests.	Dry (oak, hickory, sassafras) or sometimes moist forests and openings.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Gentiana clausa</i>	late summer	19	5	19 historic populations; 5 found in 2021. One historic record exists outside the Kendall Lake area; this record was not revisited in 2021 because it falls between transects and outside priority areas, and adjacent transects were surveyed outside the bloom period for this species. All historic records near Kendall Lake were revisited in late August, when this species was in bloom and easiest to locate. The field botanist noted that some existing populations along the lake edge are in areas with high amounts of trampling, including the use of unofficial trails. The remaining populations should be protected from foot traffic by fencing or other physical barriers. Because this is such a high use area, some historic populations that were not relocated may have been lost.	Disturbed habitats, floodplains, forests, meadows, and fields	This species is found in marshy to swampy areas such as pond margins, wet woods and ditches. Species associates include <i>Viburnum recognitum</i> , <i>Glyceria canadensis</i> and <i>G. striata</i> . Suitable habitat for this species occurs on calcareous alluvium, seeps and roadcuts throughout the CVNRA. Additional populations are expected to be located.
<i>Gentianella quinquefolia</i>	August–October	1	0	1 historic population; not relocated in 2021. The historic population was revisited briefly in late August. A more exhaustive survey might still relocate this record.	Stream and river banks, marshy meadows; bluffs and forested hillsides; usually in more or less calcareous sites.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

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<i>Gentianopsis crinita</i>	Sept-Oct	42	8	42 historic populations; 8 found in 2021. The historic records are clustered near Stumpy Basin, Wheatley Rd UHA, Station Railroad Cut UHA, along the Hike and Bike Trail, at the north end of Boston-Brandywine HVEZ, and scattered through the Cuyahoga floodplain portion of Brecksville reservation. In 2021, multiple populations were found along the Hike and Bike Trail, one population in Stumpy Basin, and one new population along the East Rim Trail. Many of the areas around historic records were surveyed too early in the season to detect this species.	Meadows, moist prairies, and moist shores; wet slopes and banks; ditches, moist old fields and roadsides; usually on calcareous sands and gravels; sometimes in drier, sandier settings than <i>G. virgata</i> .	(<i>Gentiana crinita</i> in Andreas report) Occurs on calcareous soils, primarily moist seeps and thickets. Species associates include <i>Sorghastrum nutans</i> , <i>Andropogon scoparius</i> , <i>A. gerardi</i> , <i>Solidago</i> sp, and <i>Carex</i> sp. Suitable habitat for this species occurs in oxbows and marshes along the Cuyahoga River. Although more populations would be expected to be found, none were located during the 1985 and 1986 field seasons.
<i>Glyceria canadensis</i>	July–October	0	0	No historic records; no new records in 2021.	Shallow water (seldom over 6 dm) and wet borders of ponds, lakes, ditches, and marshes; also bogs, tamarack and cedar swamps, and on peaty shores.	n/a
<i>Glyceria melicaria</i>	April–May / early to midsummer	1	0	1 historic population; not relocated in 1986 Andreas survey; not found in 2021. Andreas said, “This species grows in an area in [Virginia Kendall] park with high visitor use. Rock climbing, trampling and compaction of the soil are all present threats to this area.” The historic population may have been lost, but it would be advisable to perform a single-species, targeted survey, in June or early July, around the historic population before writing it off altogether.	Swamps	Occurs in moist semi-shaded to shaded seeps, thickets and woods. Species associates include <i>Tsuga canadensis</i> , <i>Carex</i> sp, <i>Dryopteris cristata</i> and <i>Symplocarpus foetidus</i> . Potential habitat occurs for this species throughout the CVNRA and additional locations are expected to be found. Unsuccessful searches during the 1985 and 1986 field seasons could not relocate this taxon. However, the habitat still remains undisturbed and there is every reason to believe that the population at the following record still exists.

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

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<i>Goodyera pubescens</i>	July– September	5	10	5 historic records; 10 found in 2021. None of the historic records were relocated; however, most of them are in non-priority areas and were not revisited. The 10 populations found in 2021 are all new records. Associated species include <i>Fagus grandifolia</i> , <i>Tsuga canadensis</i> , <i>Quercus alba</i> , <i>Quercus rubra</i> , <i>Liriodendron tulipifera</i> , <i>Magnolia acuminata</i> and <i>Acer rubrum</i> . One population was noted has having been browsed by deer.	Almost any kind of forest, though less often in beech-maple or oak-hickory stands than in coniferous or mixed forests; often associated with pine and hemlock, sometimes in moist ground and sometimes on hummocks and stumps in cedar or white pine-hardwood swamps. Often in sandy, somewhat acidic soils.	n/a
<i>Helianthus microcephalus</i>	August– November	1	1	One historic record; 1 found in 2021. The historic record was not relocated, but it was visited too early in the season to identify this species. The new record is on a dry, oak ridgetop. Suitable habitat exists elsewhere in the park, and additional populations may yet be found. This species is difficult to identify, and the 2021 record has low confidence because while it otherwise keys out to <i>H. microcephalus</i> , some inflorescences are too large. It is recommended that this record be verified in the future.	Forests and savannas.	n/a
<i>Hepatica americana</i>	April–May	0	51	No historic records. 51 new records in 2021. This species is easily recognizable even after the flowers have senesced. Its preferred habitats (rich beech-maple forest and dry oak forest) are common throughout CUVA. This species was typically found on upper slopes in rich forests, often on the north-facing slopes above ravines.	Rich beech-maple forests, but often associated with drier sites with aspen, oak, hickory, pine, or even spruce or cedar.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

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<i>Houstonia canadensis</i>	May–June	3	0	3 historic records; not found in 2021. Historic records were revisited in August, too late to survey for this species.	Sandy banks, fields, and open savannas	n/a
<i>Hydrocotyle americana</i>	May–August	2	7	2 historic records; 7 found in 2021. One historic record was relocated. Most of the 2021 records were found in forested seeps, although one record was growing in a marsh.	Mossy coniferous swamps and forests, especially along stream banks; marshy ground, shores, and river margins; moist rich forest, especially in springy places or depressions.	n/a
<i>Hypericum ascyron</i> (<i>pyramidatum</i>)	midsummer	1	0	1 historic record; not found in 2021. Historic record was revisited in June and may not have been blooming yet.	Moist ground along rivers and streams, ditches and wet meadows, borders of marshes and swamps.	n/a
<i>Hypericum majus</i>	June– September	1	0	1 historic record; not found in 2021. Historic record was revisited on a meander survey in July, when it should have been blooming.	Moist sandy to mucky shores, excavations, interdunal hollows; marshy or sedgy ground; fens; borders of streams and cedar swamps; crevices in sandstone.	n/a
<i>Iris cristata</i>	March–May	3	1	3 historic records; 1 found in 2021. The 2021 surveys started after peak bloom for this species, though it is recognizable when not in flower. The record found in 2021 is near one of the historic records, in the Columbia Run SRZ. The population was growing on a steep mesic forested slope, above a ravine containing several seeps. Of the other historic records, one was revisited, and the other was not.	Rocky, rich, wooded slopes; bluffs; sandy stream banks; well-drained, rich, acid soils.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Iris versicolor</i>	May–August / May–June	0	0	No historic records; no new records in 2021. This species is very similar to <i>I. virginica</i> ; flowers or seeds are required to distinguish between the two species. Vegetative Iris species were commonly observed in wetlands during the survey, but typically could not be confirmed to species due to the absence of reproductive features.	Wet places generally: lake shores, marshes, river borders, stream bottoms, meadows, ditches, swamps, and sphagnum bogs.	n/a
<i>Isotria verticillata</i>	April–June	3	0	3 historic records; not found in 2021. The records in Ritchie Ledges were searched for extensively but not found; the field botanist noted, “a lot of trampling in areas with historic records.” The remaining record was not revisited until August, when it would not have been blooming.	Local in older tamarack or black spruce zones of sphagnum bogs; much less often in moist mixed second growth forests on sandy, acidic soil.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Juglans cinerea</i>	—	25	9	25 historic records; 9 found in 2021. Surveying for this species is complicated by its similarity to <i>Juglans nigra</i> , which is extremely common in CUVA, particularly on the floodplain of the Cuyahoga River. Noticing that a particular <i>Juglans</i> is <i>cinerea</i> rather than <i>nigra</i> is largely a matter of luck. Botanists initially recorded many uncertain records, which had to be discarded due to lack of data to distinguish them from <i>J. nigra</i> . Fruit is usually necessary to confidently distinguish the two species, but fruit is not always available. Most of the records found in 2021 are new. This probably means there are more individuals that have never been documented. Of the 9 populations found, 3 were reported in good condition, 4 in fair condition, and 2 in poor condition. Cankers, epicormic sprouting, and other signs of stress were observed in most of the populations.	Stream banks and swamps; upland beach-maple, oak-hickory, or mixed hardwood stands.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Juncus greenei</i>	July–August	1	0	1 historic record; not found in 2021 survey. Andreas noted that, “This species grows in an area created by the building and maintenance of the turnpike bridge. The area is presently used to park service vehicles, heavy equipment and employee cars. All of these activities have the potential to destroy the population ... The Ohio Turnpike Commission should be notified that this area houses rare species so that they might re-direct their activities to avoid damaging this population.” EnviroScience did not revisit this record, as it did not fall on a transect and was not in a priority area. Based on recent satellite imagery and Google Street View, the area is no longer being used to store vehicles and equipment but appears invaded with Phragmites and other opportunistic species. It would be worth revisiting the area and performing a single-species, targeted survey.	Moist to dry sandy open ground: shores, swales, fields, clearings, dunes, and interdunal depressions.	Occurs in moist sandy fields, thickets, and clearings, often calcareous. Species associates include <i>Typha latifolia</i> , <i>Triglochin maritima</i> and <i>Chenopodium glaucum</i> . There is little suitable habitat for this species within the CVNRA and no additional populations are expected to be located.
<i>Juniperus communis</i>	–	28	20	28 historic records; 20 records found in 2021. This species is primarily found on the upper slopes along the eastern edge of Stumpy Basin. These slopes are generally slumping to some degree, and most populations are located in and around canopy gaps, forest with sparse canopy, or the forest edge.	On or near sandy shores and dunes along Great Lakes, often associated with pines; also inland in a diversity of habitats (old fields and gravelly banks, usually with scattered red-cedar in “juniper savannas”); also occasionally in coniferous swamps (on hummocks) or in oak-hickory forests.	Occurs on steep eroding calcareous slopes. Species associates include <i>Sorghastrum nutans</i> , <i>Shepherdia canadensis</i> , <i>Andropogon gerardi</i> and <i>Siliphium trifoliatum</i> . Potential habitat occurs for this species on eroding slopes throughout the CVNRA and additional locations are expected to be found.
<i>Lactuca floridana</i>	August–October	0	0	No historic records; no new records in 2021.	Rich woods, thickets, and clearings; moist to wet open woods, thickets, disturbed sites, waste ground, streambanks, roadsides and railroads.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Lechea intermedia</i>	June–July	9	1	9 historic records, 1 found in 2021 in a power line right-of-way above the Sagamore Creek gorge in Bedford Reservation.	Sandy or rocky ground: plains (with jack pine, oak, and/or aspen), outcrops, shores.	Occurs in dry, sunny to semi-shaded banks and thickets. Species associates include <i>Phlox subulata</i> , <i>Aster laevis</i> , <i>Solidago bicolor</i> , <i>Nyssa sylvatica</i> and <i>Danthonia spicata</i> . Suitable habitat for this species occurs on dry areas along the summit of steep, open ravines along the Cuyahoga River. Although more populations would be expected to be found, none have to date.
<i>Lespedeza frutescens</i>	mid to late summer	2	12	2 historic records; 12 found in 2021. The historic records were not revisited because they fall between transects and are not in priority areas. More than half of the 2021 records are from the upper slopes on the eastern edge of Stumpy Basin.	Dry usually more or less open forests (especially oak), thickets, banks, and prairies.	n/a
<i>Lespedeza hirta</i>	late summer	4	8	4 historic records; 8 found in 2021. Three records found near Kendall Lake; historic record was directly in center of lake, so it probably represented at least one of the three found in 2021. The other historic record was not revisited because it was between transects and outside the priority area. It was found in dry-mesic oak forests, or dry-mesic fields and clearings adjacent to dry-mesic oak forest, often on ridgetops. The edges of powerline ROWs through dry-mesic oak forest, particularly near steep bluffs above rivers and streams, would be good habitat to search for additional populations.	Dry open usually sandy ground, including fields, roadsides, and river banks; oak and oak-hickory forests.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Lespedeza procumbens</i>	July–October	0	1	No historic records, one found in 2021 northwest of Blossom Music Center, growing near records for <i>L. frutescens</i> and <i>L. hirta</i> .	Bottomland and mesic upland forests, glades, upland prairies, streambanks, old fields, ditches, railroads, and roadsides.	n/a
<i>Liatris aspera</i>	August–September	0	0	No historic records; no new records in 2021.	Dry sandy prairies, fields, plains, clearings, and oak or jack pine savannas; associated roadsides and railroads.	n/a
<i>Linum striatum</i>	mid June to late August	1	1	One historic record not relocated in 2021; one new record in 2021. The historic record was revisited in early September when it would have been past blooming but still probably identifiable. The new record is on a steep slope in dry-mesic oak forest.	Dry to (usually) moist sandy shores, even marshy places and sometimes with jack pine.	n/a
<i>Linum virginianum</i>	June–July	1	3	1 historic record, not relocated, and 3 new records in 2021. The historic record was not revisited in 2021. Two of the new records were found in power line rights-of-way, and one was in a canopy gap on a dry forested ridge.	Dry forests, hillsides, and sandy banks; also moist shaded ground, shores, and river banks. Upland or alluvial, open woods; thickets; clearings; stream banks.	n/a
<i>Liparis liliifolia</i>	late spring to mid summer	0	0	No historic records; no new records in 2021.	Thriving in areas once cultivated or disturbed. Brushy second-growth thickets and mixed forests, floodplains, pine plantations.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

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<i>Liparis loeselii</i>	June–July	2	0	2 historic records; not found in 2021. Both historic records were revisited on meander surveys without being relocated. One historic record with only two recorded plants was visited in June, which is within this species' flowering period. Given the plant's small size, flower color (green) and habitat preference (“generally hidden in grasses and sedges”—MI Flora) it could have been missed during this survey. The other record, with 50+ plants documented in 1986 was visited in September and would not have been flowering. Recommend revisiting at least the larger historic population during June.	Generally hidden in grasses and sedges of fens (open mat to older tamarack and cedar swamps), marshy shores, beach pools and interdunal swales, marly flats, roadside excavations, ditches, springs, and stream beds.	Grows in calcareous soils such as open hillside seeps, fens, and thickets. Species associates include <i>Silphium trifoliatum</i> , <i>Gentiana crinita</i> , <i>Sorghastrum nutans</i> and <i>Muhlenbergia</i> sp, <i>Carex interior</i> , <i>Carex aurea</i> , <i>Carex atlantica</i> and <i>Salix</i> sp. Suitable habitat ... occurs on moist calcareous seeps and alluvium throughout the CVNRA.
<i>Lobelia spicata</i>	midsummer	0	5	No historic records; 5 found in 2021. Three above Stumpy Basin. Two on occasionally mowed grassy berms near manmade lakes.	Open areas, usually at least seasonally wet, including meadows, fields, shores, calcareous flats and rocky openings, edges of swamps and marshes, oak savanna, prairies.	n/a
<i>Lonicera canadensis</i>	May–June	2	0	2 historic records; not found in 2021. The historic records were not visited on meander surveys, but fall within 15–30 meters of a transect line, and therefore have a good chance of being detected when those transects were surveyed. This species can be detected any time during the growing season, although it is easiest to identify when flowers or fruit are present. Although disturbance data was not collected when rare plants were not found, anecdotally, the forest understory around one historic record (in Bedford Reservation) is almost non-existent due to over browsing by deer.	Forests of all kinds: beech-maple-hemlock, aspen, oak, mature red and white pine, spruce-fir, and mixed conifer-hardwoods; swamps, especially cedar.	In semi-shaded to shaded sandstone cliffs and ledges, rocky hillsides and hemlock gorges. Species associates include <i>Tsuga canadensis</i> , <i>Betula alleghaniensis</i> , <i>Taxus canadensis</i> and <i>Acer spicatum</i> . Suitable habitat ... occurs on dry areas along the summit of steep, open ravines along the Cuyahoga River. Although more populations would be expected to be found, none have to date.

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

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<i>Lupinus perennis</i>	April–July	0	0	No historic records; no new records in 2021.	Dry usually sandy ground, ranging from prairies and open barrens or clearings to savannas of oak, jack pine, and/or aspen.	n/a
<i>Maianthemum stellatum</i>	May–June	0	1	No historic records; 1 found in 2021. Growing on an old, unpaved road in dry-mesic oak forest.	Particularly characteristic of sand ridges, dunes, and shores (and neighboring thickets) near the Great Lakes, where the plants are stiffly erect with the leaves strongly ascending and somewhat folded or trough-like. In rich hardwoods, thickets along river banks, floodplains and deciduous swamps, coniferous swamps, and other shades sites plants are more similar to <i>M. racemosum</i> in aspect, with an arching stem and flat blades.	n/a
<i>Melanthium virginicum</i>	June–July	2	0	2 historic records; not found in 2021. The two historic records are two observations of the same population. It was revisited in September, too late to identify this species.	Open bottomland woodlands, damp meadows, swamps, marshes, fens, floating bogs, and roadside ditches.	n/a
<i>Moehringia lateriflora</i>	May–June	2	1	2 historic records of same population, relocated in 2021. Growing on a moist, old road grade and its adjacent berms on the edge of an old pine plantation and mixed hardwood forest.	Usually in moist, more or less open forests and bluffs	n/a
<i>Monotropa hypopitys</i>	June–September	8	16	8 historic records; 16 found in 2021, mostly in dry-mesic oak forest. 4 historic records revisited but not found; 4 records re-located.	Coniferous or deciduous forests or even conifer swamps.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

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<i>Morella pensylvanica</i>	–	0	1	No historic records; 1 found in 2021. This species was not on the original list but is a suggested addition to the list. Located in old field habitat within a clearing with evidence of past earth scraping along I-271, south of Brandywine Falls. Possibly spreading vegetatively, and may represent an escape from cultivation and not a native population	Native around the margins of and in large fens in Barry and Washtenaw Cos [Michigan]. Sometimes planted for wildlife, and collections from sandy upland fields in Washtenaw and Monroe Cos. are escapes from old plantings, with the spread mostly, if not entirely, vegetative.	n/a
<i>Morus rubra</i>	–	4	0	4 historic records; not found in 2021. One record revisited but not found; one record not revisited because it was between transects; two historic records not revisited because they were outside the study area.	Floodplains, river bottoms, and swamps.	n/a
<i>Muhlenbergia sobolifera</i>	July–October	5	0	5 historic records; not found in 2021. There are many similar-looking grasses, and this species could have reasonably been overlooked. Targeted surveys would be the best way to find it.	Dry upland forests, oak woodlands, and on rock outcrops of sandstone, chert, or limestone formations.	n/a
<i>Myosotis verna</i>	April–July	0	0	No historic records; no new records in 2021.	Dry sandy or rocky banks (both grassy and forested), meadows and pastures, oak savanna.	n/a
<i>Nabalus albus</i>	August–September	0	0	No historic records; no new records in 2021.	Deciduous forests (beech-maple, northern hardwoods, oak, aspen) especially along borders and clearings; thickets, moist forests, river banks, occasionally even floodplain forests; rock outcrops, jack pines.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

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<i>Orchis spectabilis</i> (<i>Galearis spectabilis</i>)	May–June	4	24	4 historic records, not relocated in 2021; 24 new locations found in 2021. Most frequently associated with <i>Liriodendron tulipifera</i> and <i>Fagus grandifolia</i> ; also <i>Acer saccharinum</i> , <i>A. saccharum</i> , and <i>Quercus rubra</i> . Botanists noted that several populations were browsed by deer.	Moist rich hardwoods, often along streams and around seeps.	n/a
<i>Orobanche uniflora</i>	late spring to early summer	12	0	12 historic records; not found in 2021.	Local, at edges of conifer thickets along dunes; even more local inland, in both dry sandy open areas and rich forests. Symphyotrichum and Solidago are only hosts verified in MI.	n/a
<i>Orthilia secunda</i>	June–July	2	0	2 historic records; not found in 2021. Andreas was also unable to relocate historic records of this species in 1985–86.	Moist forests, coniferous and mixed; borders of thickets and dunes; sometimes in deciduous forests and other drier places.	This historical record was not observed during the 1985 and 1986 field seasons, although numerous attempts were made to re-locate this species. Its habitat affinities within the CVNRA are unknown. Elsewhere in Ohio, <i>Pyrola secunda</i> has been associated with dry oak-beech woods in the thin soil on top of rock outcrops.

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

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<i>Oryzopsis asperifolia</i>	May–July	34	0	34 historic records; not found in 2021. Most of the historic records are scattered through the forested areas of Brecksville Reservation that fall outside any CUVA Management Zone. Dry beech/maple/oak forests occur on ridges in this area, but anecdotally, the soils are not particularly high in humus, as mentioned in Andreas’ habitat affinity description. Several rare plant records in this vicinity had the highest IERAT score, indicating a high level of disturbance from invasive earthworms, leading the author to speculate that earthworms may be a significant threat to this species, by destroying the humus content of soils.	Found in a great variety of forests, including rich deciduous forests and hemlock-hardwoods, but most characteristic of rather dry open forests associated with jack pine, oak, and/or aspen; on forested dunes with pine and in rocky mixed forests.	Dry, high-humus soils under beech, maple and oak. Associated spp include <i>Carex pedunculata</i> , <i>Carex willdenowii</i> , <i>Comandra umbellata</i> and <i>Panicum</i> sp. Elsewhere in Ohio it occurs in semi-shaded woods including mature oak woods and hawthorn thickets. Similar communities throughout the CVNRA were examined, but this species was not found elsewhere.
<i>Oxalis grandis</i>	June–September	1	4	1 historic record; 4 records in 2021. Dry-mesic oak forest. Three populations in fair condition, loosely rooted in worm-disturbed soils, with insect and deer browse damage.	Sandy woods, alluvial soils	n/a
<i>Oxalis violacea</i>	April–June	12	7	12 historic records; 7 found in 2021. In dry-mesic oak forest, associated with <i>Quercus alba</i> , <i>Q. rubra</i> , <i>Acer saccharum</i> , <i>Carya ovata</i> and <i>Platanus occidentalis</i> .	Usually sandy open woods, banks, rocky ground, and prairies.	n/a
<i>Panax quinquefolius</i>	early summer	10	12	10 historic records; 12 found in 2021. The 2021 survey found between 1 and 26 plants per location. Records for this species were found in rich forests with a diverse herbaceous understory.	Rich, even swampy, hardwoods (beech, sugar maple, hemlock), especially on slopes or ravines.	Rich mesic woods, stream terraces and hemlock gorges. Species associates include <i>Acer rubrum</i> , <i>Acer saccharum</i> , <i>Fagus grandifolia</i> , <i>Dryopteris marginalis</i> and <i>Viburnum acerifolium</i> . Potential habitat occurs ... throughout CVNRA and additional locations are expected to be found.

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

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<i>Parnassia glauca</i>	August–September	1	0	1 historic record; not found in 2021. The historic record was revisited but not re-located in 2021 during a meander survey at the end of September, when this species would have been in bloom. Extensive meander surveys were conducted in Stumpy Basin throughout the growing season, but no populations of <i>Parnassia glauca</i> were found.	Calcareous sandy and gravelly shores, interdunal flats, meadows, stream banks, fens, and marshes.	Calcareous soils such as hillside seeps, alluvium and fens. Species associates include <i>Scirpus americanus</i> and <i>Carex</i> sp. Suitable habitat for this species occurs on calcareous seeps and alluvium throughout the CVNRA.
<i>Pedicularis lanceolata</i>	August–September	1	12	1 historic record; 12 found in 2021. Historic record revisited in August but not relocated. New records were found in seeps and in wetlands within valley bottoms and along Kendall Lake. One population was in mowed lawn habitat along the edge of Kendall Lake. Botanists noted that several populations were browsed by deer.	Borders of marshes, swamps, ponds, and lakes; river banks, thickets, and springy slopes; fens (even in Sphagnum), meadows, and wet prairies.	n/a
<i>Penstemon hirsutus</i>	May–June	0	1	No historic records; 1 found in 2021. In dry-mesic oak forest. Only one individual found.	Sandy, barren, open, usually dry ground, including prairies, oak savanna and borders, fields, roadsides; stream and river banks, rocky ground.	n/a
<i>Phlox maculata</i>	August–October / May–September	0	0	No historic records; no new records in 2021.	Bottomland woodlands, woodland openings, moist meadows along rivers, banks of rivers, fens, roadsides in wooded areas, and abandoned fields.	n/a
<i>Phlox pilosa</i>	May–July / March–May	0	1	No historic records; 1 found in 2021, at the top of a slope above Stumpy Basin.	Dry sandy forests with oak and hickory, even in barren and disturbed sites; also prairies, fens, and borders of swamps.	n/a
<i>Phlox subulata</i>	April–June	0	0	No historic records; no new records in 2021.	Part shade, sun; dry sandy or rocky soil; barrens, woods, rock ledges, gardens.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Piptatherum racemosum</i>	May–June	2	0	2 historic records; not found in 2021. The two historic records are apparently duplicates, representing only one population. Not revisited in 2021, because it falls between transects and outside a priority zone.	Usually in moist, rich deciduous forests and forested dunes, sometimes in disturbed places.	n/a
<i>Platanthera lacera</i>	June–July	0	1	No historic records; 1 new record in 2021. This species was not on the original list but is a suggested addition to the list. The 2021 record consisted of a single individual near the edge of an open field south of Kendall Lake. Because the habitat is dominated by tall, dense herbaceous vegetation and the flowers are green and white, this species is quite inconspicuous and may be scattered within this area.	In bogs and fens, both open and under tamarack or cedars, but also in wet ground generally: moist meadows, ditches, edges of moist forests, swampy thickets. Widespread, but not usually in large numbers at any one site.	n/a
<i>Platanthera orbiculata</i>	July–August	32	4	16 historic records were revisited during the 2021 growing season but were not relocated. Of the records revisited but not found, these are of note: 1) A 3-record cluster in the Blue Hen Falls UHA; 2) a 2-record cluster northeast of Blue Hen Falls, in the Columbia Run SRZ; 3) 4 records in Ritchie Ledges UHA. and 4) 3 records north of Yellow Creek. The 4 populations found in 2021 are apparently new records. This implies that while some historic populations may have been lost, there may be new populations yet to be found. Keeping deer population at sustainable levels in areas of suitable habitat for this and other orchids would be advisable.	Rich deciduous or mixed forests; coniferous forests from virgin pine to swamps of cedar, balsam fir, hemlock, etc.	Dense shaded or semi-shaded rich beech-maple or mesic woods. Species associates include <i>Acer saccharum</i> , <i>Fagus grandifolia</i> , <i>Betula alleghaniensis</i> , <i>Cryptotaenia canadense</i> , <i>Thelypteris noveboracensis</i> , <i>Festuca obtusa</i> and <i>Viburnum acerifolium</i> . Potential habitat occurs for this species throughout the CVNRA and additional locations are expected to be found. This orchid may live for years underground as a saprophyte. This species may be more common than records indicate.

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Poa languida</i>	June–August	7	0	7 historic records; not found in 2021. This species bears a close resemblance to several extremely common species in the same genus. Therefore, it is possible that populations of <i>Poa languida</i> were overlooked. To reliably inventory this species in the park, additional surveys for a limited number of grass species would be advisable.	Forests, shores, and thickets	Dry oak woods, eroding slumps and dry hogbacks. Species associates include <i>Quercus alba</i> , <i>Quercus rubra</i> , <i>Fagus grandifolia</i> , <i>Caex artitecta</i> , <i>Carex pensylvanica</i> , <i>Anemonella thalictroides</i> , <i>Viburnum acerifolium</i> and <i>Mitchella repens</i> . Potential habitat occurs for this species throughout the CVNRA and additional locations are expected to be found.
<i>Poa palustris</i>	April	2	1	2 historic records; one found in 2021. This species is easily overlooked due to its superficial similarity to other common grasses.	Shores, meadows, and moist to wet ground generally; pond and stream banks; openings in coniferous and deciduous forests and swamps; bogs and marshes; sometimes on drier sandy or rocky ground.	n/a
<i>Polygala senega</i>	May–July	1	0	1 historic record, not relocated in 2021. Outside the study boundary, not revisited.	A diversity of forested, swampy, rocky, or even prairie-like habitats, shores and banks.	n/a
<i>Potamogeton natans</i>	June–September	3	0	3 historic records, not relocated in 2021. Two records revisited without success; one not visited because it's between transects.	Lakes and rivers; also ditches, ponds, bogs; usually in fairly shallow water (to 1.5 meter) but recorded at depths to 3.7 meters.	n/a
<i>Prenanthes crepidinea</i>	August–September	1	1	Historic record not relocated. New record is listed as low confidence; identity not confirmable due to low-quality photographs. Botanist noted a large population (~1000) so it should be easy to relocate to confirm.	Rich floodplain forests; openings in mesic to dry-mesic hardwoods, particularly along creeks and in seepage areas.	n/a
<i>Prunus americana</i>	April–May	2	4	2 historic records, not relocated in 2021; 4 new records found in 2021. In successional meadow, shrub-scrub, and forest communities. Associated with oak spp.	Sandy open to forested sites; along streams, ponds, lakes, and borders of forests; fencerows and roadsides.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Prunus pensylvanica</i>	late spring	0	0	No historic records; no new records in 2021. If further surveys are planned for this species, they should occur in late summer or fall, after fruit is developed. <i>Prunus</i> spp are easiest to identify when fruit is present.	Sandy clearings, shores, and plains; borders of forests and fields and in open (rarely swampy) forests, usually with aspen, white birch, and/or jack pine.	n/a
<i>Pycnanthemum muticum</i>	July– September	8	31	8 historic records; 31 found in 2021. Mostly in open plant communities, occasionally in shrub-scrub or forest. 9 populations had 100 or more individuals.	Anthropogenic; cliffs, balds, or ledges; meadows and fields; ridges or ledges; woodlands.	n/a
<i>Quercus imbricaria</i>	–	11	21	11 historic records; 21 found in 2021. 4 historic records revisited but not relocated. Associated with other oaks and other hardwoods including red maple, shagbark hickory, wild black cherry, black walnut. Most records were in Virginia Kendal HVEZ.	Upland woodlands, well-drained areas of floodplain woodlands, wooded slopes and edges of bluffs, tall riverbanks, edges of limestone glades, sandstone cliffs, and fencerows.	n/a
<i>Ranunculus fascicularis</i>	April–May	0	0	No historic records; no new records in 2021. If further surveys are planned for this species, they should occur in spring or early summer, when this species is in bloom.	Sandy oak savanna, dry grassy openings and prairies; shallow soil over limestone pavement; rock outcrops, ledges, and “balds.”	n/a
<i>Rhamnus alnifolia</i>	May–June	0	2	No historic records; 2 found in 2021 in a wetland along Salt Run, southeast of the intersection of Akron Peninsula Road and Truxell Road.	Fens, openings in tamarack and cedar (sometimes also spruce) swamps, peaty streamside thickets, interdunal swales, sedge marshes and mat, sometimes in wet, open deciduous forests, rocky openings and outcrops; generally a calciphile and a good indicator of fens.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Rhexia virginica</i>	May–September (July–August)	2	0	2 historic records; not found in 2021. Historic record is near a transect surveyed in late July, when <i>Rhexia</i> would probably have been in bloom.	Sunny, moist, sandy to mucky shores and swales, in acid soil.	n/a
<i>Rhus aromatica</i> var. <i>aromatica</i>	yellow flowers before leaves, and red fruit and foliage in fall	1	2	1 historic record; 2 found in 2021. Historic record not relocated; 2 new records found. One near I-80 on the northern slopes of Stumpy Basin. One near CVSR train yard, may have been planted.	Sandy, gravelly soil, open or with oak, hickory, and/or pine; river banks; thin soil over limestone	n/a
<i>Salix humilis</i>	–	0	1	No historic records; 1 new record in 2021. This record consisted of about 8 individuals growing on a steep slope on the northern edge of Stumpy Basin, along I-80.	Usually in dry sandy or rocky ground, often with jack pine and oak, but sometimes on moist sites.	n/a
<i>Schoenoplectus americanus</i>	April–August	0	0	No historic records; no new records in 2021.	Salt marshes.	n/a
<i>Sericocarpus asteroides</i>	June–August	3	1	3 historic records; 1 found in 2021. One historic record relocated, two revisited but not found. The one record found is in dry mesic oak forest, atop a steep bluff above the Cuyahoga River floodplain.	Dry woods and wood margins.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Shepherdia canadensis</i>	late April–May (fruit in early summer)	13	1	13 historic records; 1 found in 2021, on a heavily slumping slope along Stumpy Basin. Most of the historic records were revisited without success, with the notable exception of two historic records in Bedford reservation which were not visited because they are not near transects and not in a priority area. Since this species grows on steep, slumping hillsides, not all promising habitat can be accessed safely. <i>Shepherdia canadensis</i> bears a superficial resemblance to two invasive species of shrub, <i>Elaeagnus umbellata</i> and <i>Lonicera morrowii</i> , which are both common throughout the park. When performing invasive shrub control in areas that could have suitable habitat for this species, all workers should be informed of this fact, and review distinguishing characteristics to ensure they do not accidentally kill this Potentially Threatened species. The similarity of this species to two widespread invasive species adds difficulty to attempts to search for a plant that would otherwise be quite easy to spot from a distance. In fact, one of the botanists initially walked past the 2021 record, dismissing it as <i>Elaeagnus umbellata</i> which was also growing on the same slope. More populations of this species are likely present on the Stumpy Basin slopes.	Dunes, gravelly and rocky shores, ridges, openings; rock outcrops (especially limestone); open forests (aspen, pine, birch, cedar, fir); clay and calcareous river banks; moist thickets, even fens.	Upper regions of calcareous slumps. Species associates include <i>Juniperus communis</i> , <i>Quercus velutina</i> , <i>Sorghastrum nutans</i> , <i>Carex pensylvanica</i> and <i>Solidago bicolor</i> . Potential habitat occurs for this species on eroding slopes throughout the CVNRA and additional locations are expected to be found.

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Silphium laciniatum</i>	midsummer	2	1	2 historic records; one found in 2021. The population found in 2021 is not near either historic record but is in a planted prairie next to a parking area, and is therefore probably planted. The historic location near Ira Road does not have detailed location data, so there's no way of knowing if this population was revisited. The historic location point near Steels Corners Rd falls in inappropriate habitat (forest), but there are several clearings nearby that could have prairie-like habitat. Parts of this area were surveyed, but not all potential habitat in the area was visited in 2021.	Prairies, savannas, glades, and railroad ROW.	The records for this species within CVNRA are historical and habitat affinities are unknown. Elsewhere in Ohio, this species is associated with prairie vegetation.
<i>Solidago squarrosa</i>	August– September	10	0	10 historic records; none found in 2021. Most historic records fall outside priority areas and between transects, and were therefore not revisited during the 2021 survey. A meander survey revisited two historic locations in Boston-Brandywine HVEZ in mid September, when this species should have been in bloom and identifiable. The botanist found appropriate habitat for this species, including dry oak forest and the edges of a clearing, ridgetop and upper slopes.	Dry woods, fields, and rocky slopes	Shaded to semi-shaded open oak and oak-beech woods. Species associates include <i>Solidago bicolor</i> , <i>Quercus alba</i> , <i>Q. rubra</i> and <i>Aster laevis</i> . Potential habitat occurs for this species throughout CVNRA and additional populations are expected to be located.
<i>Solidago ulmifolia</i>	July– September	1	2	1 historic record; 2 found in 2021. Historic record between transects, not revisited. One new location on edge of plateau in dry-mesic oak forest above steep slope. One new location halfway down a steep slope in beech-maple forest, below a dry, oaky ridgetop.	Oak forests; shades shores and banks	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Sphenopholis pensylvanica</i>	late May to early July	2	0	2 historic reports; none found in 2021. The two historic records are very close together and may be just two different interpretations of the same observation. The location was re-visited in mid-September 2021. As this species blooms in mid-May–late June, it may not have been identifiable at the time of survey. The area should be revisited earlier in the season.	Marshes, meadows and fields, shores of rivers or lakes, swamps	(<i>Trisetum pensylvanicum</i> of Andreas report) Calcareous soils on hillside seeps, alluvial floodplains and fens. Species associates include <i>Carex</i> . spp, <i>Symplocarpus foetidus</i> , <i>Dryopteris cristata</i> and <i>Senecio aureus</i> . Potential habitat occurs on calcareous hillside seeps and wet woods throughout the CVNRA.
<i>Spiranthes cernua</i>	August–September	0	2	No historic records; 2 found in 2021. This species was not on the original list but is a suggested addition to the list. One of the 2021 populations was on a forested slope on the eastern edge of Stumpy Basin, and the other was on a lower forested slope between I-80 and I-271, a short distance north of Stumpy Basin.	Shores, ditches, grassy roadsides and openings, sandy excavations, meadows, beach pools and interdunal swales, shaded rock ledges northward; often in sandy soil, sometimes marly or peaty, at bog borders.	n/a
<i>Spiranthes lacera</i>	July–September	0	2	No historic records; two new records found in 2021. The new records are within 15 meters of each other, and would more appropriately be considered a single population, of about 25 plants. They are right next to the Hike and Bike trail and the botanist who observed them commented that they are at risk of being mowed.	Characteristic of dry sandy soil of jack pine plains, often with blueberry and bracken; also under red pine and oak, in moist aspen forests and conifer thickets along shores and dunes, and in thin soil on rocks in western UP.	n/a
<i>Spiranthes lucida</i>	May–July	10	0	10 historic records; none found in 2021. Has overlapping habitat requirements with <i>S. magnicamporum</i> . Some historic records of this species were revisited while surveying for <i>S. magnicamporum</i> , which blooms later in the season. Recommend return visits during late May–early June to survey for this species.	Stream banks, lake shores, seeps on hillsides; in calcareous sands, muck, or marl, often in somewhat disturbed sites; very local.	Calcareous alluvium. Species associates include <i>Carex interior</i> , <i>Carex atlantica</i> , <i>Physocarpus opulifolia</i> , <i>Liparis loeselii</i> and <i>Rosa palustris</i> .

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

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<i>Spiranthes magnicamporum</i>	August–October	28	27	28 historic records; 27 found in 2021. The historic records in Station Road Railway Cut UHA were revisited in early September, which is early in the bloom period for this species. The records were not re-located; the botanist noted that half of the UHA is swamp surrounded by multiflora rose. This could indicate that the <i>S. magnicamporum</i> has been shaded out by invasive species or natural succession from disturbed clearing to swamp forest. Historic populations near East Rim Trailhead were re-located and have a collective population of several hundred plants. Several new populations were found along the southern leg of East Rim Trail. This species is abundant in the large open field east of Stumpy Basin. This species may benefit from a moderate level of disturbance; however, care should be taken to keep visitors on-trail, and trail maintenance should not include stabilizing any slopes as this and other rare species benefit from natural slumping and erosion. A new population was found southeast of the overflow parking lot for East Rim Trail. The field botanist said of the risk of human impacts to this population, “anthropogenic trails evident throughout barren. Worrisome.”	Wet calcareous meadows, fens, moist to dryish prairies and prairie-like habitats, in calcareous soil.	Calcareous seeps and slumps that support a prairie-like flora. It closely resembles <i>Spiranthes cernua</i> and the two species may be found in close proximity. Species associates include <i>Silphium trifoliatum</i> , <i>Gentiana crinita</i> , <i>Aster laevis</i> , <i>Sorghastrum nutans</i> and <i>Carex</i> sp.
<i>Spiranthes ovalis</i>	September to November	16	8	16 historic records. 8 populations found in 2021.	Moist fields, moist to dry shrub thickets, open forests, and prairie-like habitats.	n/a
<i>Spiranthes tuberosa</i>	August	1	0	1 historic record; not found in 2021. Revisited in July and September.	Meadows and prairies, in dry to moist sandy acid soils, sometimes under bracken, or in Polytrichum mats, very local.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

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<i>Sporobolus michauxianus</i>	midsummer to early fall	0	0	No historic records; no new records in 2021.	Most characteristic of marshes, wet prairies, and sandy shores, but sometimes in dry sand, especially near the Great Lakes shores.	n/a
<i>Symphoricarpos orbiculatus</i>	late spring to summer	3	46	3 historic records; 46 found in 2021. (3 historic records relocated, 43 new records found.) Mostly in successional, beech-maple and dry-mesic oak forest types. Some populations had some branches without leaves; unclear whether from deer browse, insect damage, or another cause. This species is known to escape from cultivation, and it is difficult to determine whether recorded populations would be considered native or not.	Thin rocky woodlands, woodland openings, woodland borders, areas along woodland paths, powerline clearances in wooded areas, thickets, and limestone glades.	n/a
<i>Symphyotrichum oolentangiense</i>	August–October	0	5	No historic records; 5 new records in 2021, however these records are labeled as having low to medium confidence and should be verified in the future.	Savannas of oak (with hickory, sassafras, and/or pine); dry open sandy ground as well as moister prairies	n/a
<i>Taxus canadensis</i>	–	7	1	7 historic records representing 3 populations; 1 historic record re-located in 2021. This species should not be confused with <i>Taxus baccata</i> or <i>T. cuspidata</i> , which are common landscaping plants and sometimes escape cultivation in disturbed areas.	Rich often swampy forests: deciduous, mixed, or coniferous, often thriving on banks and in ravines.	n/a
<i>Tipularia discolor</i>	August	0	1	No historic records; 1 found in 2021. This species was not on the original list but is a suggested addition to the list. The 2021 record was located in a dry mesic oak forest east of Kendall Lake. The dull yellow and purple flowers blend into the leaf litter making this species very inconspicuous.	Rich, sandy deciduous woods, both oak and beech-sugar maple.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

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<i>Triglochin maritima</i>	May–August	1	0	1 historic record; none found in 2021. Historic record is behind a fence, part of the turnpike right-of-way. See comments at <i>Juncus greenei</i> .	Gravelly and marly shores, wet sandy beaches and interdunal swales, sedge meadows and fens, stream borders.	Moist sandy fields, thickets and clearings, often calcareous. Species associates include <i>Typha latifolia</i> , <i>Juncus greenei</i> and <i>Chenopodium glaucum</i> . There is little suitable habitat for this species within the CVNRA and no additional populations are expected to be located.
<i>Valerianella chenopodiifolia</i>	May–June	1	3	1 historic record, 3 found in 2021. Associated with <i>Platanus occidentalis</i> , <i>Acer nigrum</i> , <i>Aesculus glabra</i> , <i>Acer saccharum</i> and <i>Carya ovata</i> . A large population of more than 300 plants was found in the floodplain along Boston Run, south of the Spicy Lamb Farm. A smaller population was found along Boston Run north of the Trapp Family Farm. Curiously, the third population was on a dry, upper slope near the forest edge east of the Valley Fire Station No. 1, northwest of the Trapp Family Farm.	Moist ground, especially river floodplains	n/a
<i>Vicia americana</i>	May–Sept	1	1	One historic record above Stumpy Basin, relocated in 2021. The population consisted of 31 observed individuals growing at the top of the slope along the edge of the forest and large open field.	Diversity of moist to dry, open to shades habitats	n/a
<i>Vicia caroliniana</i>	April–June	0	2	No historic records; 2 found in 2021. One on the slope along the east side of Stumpy Basin. One in Blossom Woods in steep ravine, beech-maple forest.	Oak and oak-hickory forests, borders of forests, dry open ground and clearings; less often in moist places, banks of streams and lakes.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Viola palmata</i>	mid to late spring	5	21	5 historic records. 21 found in 2021. Historic records were not relocated. New records were found on a variety of forested ridgetops and ravine slopes; associated with <i>Quercus alba</i> , <i>Acer saccharum</i> , <i>Liriodendron tulipifera</i> , <i>Fagus grandifolia</i> , and other oaks.	Dry oak, oak-hickory, or even beech-maple forests, prairies, and thickets between forests and prairies	n/a
<i>Viola sagittata</i> var. <i>ovata</i>	June	2	1	2 historic records of same population, relocated in 2021. Successional mixed hardwood forest, red oak, red maple.	Dry sandstone roadcuts or trailsides with little competition. Jack pine.	n/a
<i>Vitis vulpina</i>	late spring to early summer	1	12	1 historic record, not relocated. Of 12 records in 2021, only 6 have sufficient documentation that the plant was correctly identified. This is a challenging species to ID; there could be many more populations not previously documented. Habitat exists throughout CUVA.	Rich deciduous forests, especially along rivers.	n/a
<i>Waldsteinia fragarioides</i>	April–June	9	4	7 historic populations (9 total records, 2 are duplicates). Three historic populations relocated; one new population found in 2021. Found in successional mixed hardwood, cottonwood-sycamore floodplain, beech-maple forest, dry-mesic oak forest, and hemlock ravines.	Moist deciduous forests; open thickets, savannas, or forests.	n/a
<i>Zizania aquatica</i>	June–August	2	5	2 historic records not relocated; 5 new records found in 2021. Three records were found along the southwestern edge of Kendall Lake, the smallest of which was exhibiting injury from herbicides used along the earthen dam. One population was along the boardwalk in the Beaver Marsh, and another was in the canal east of the Station Road parking lot.	Rivers, streams, lakes, and ponds, seldom in water much over 6m deep.	n/a

Table E-1 (continued). Discussion of 2021 records, comparison to historical records, and habitat preferences from MI Flora and Andreas 1986 report. CVNRA (in quotes from the 1986 Andreas report) refers to Cuyahoga Valley National Recreation Area, before it was designated a national park. Priority Zone abbreviations: UHA = Unique Habitat Area; HVEZ = High Value Experience Area; SRZ = Sensitive Resources Zone. “No historic records” means that there were no records in the historic rare plant data ES was able to obtain. In the case of plants which are not state-listed, or were added to the list recently, the plant would not have been included in historic rare plant records even if it was known to occur in the study area historically.

Scientific Name	Bloom Timing	Historic Records	2021 Records	Discussion	Documented Habitat Description (Source: MI Flora)	Documented Habitat Affinities (Source: Andreas 1986)
<i>Zizania palustris</i>	July–October	0	0	No historic records; not found in 2021.	Same habitats as <i>Z. aquatica</i> , but much more common.	n/a

Appendix F. Factor analysis details

Tables F-1 and F-2 provides additional details on the factor analysis.

Table F-1. Eigenvalues and total and cumulative percentage of total variance explained for each of the 16 factors extracted from the correlation matrix of environmental variables using factor analysis with the principal component method.

Factor	Eigenvalue	Percent of Total Variance Explained	Cumulative Eigenvalue	Cumulative Percentage of Total Variance Explained
1	3.033	8.66	3.033	8.66
2	2.637	7.54	5.67	16.2
3	2.438	6.97	8.108	23.17
4	1.945	5.56	10.053	28.72
5	1.715	4.9	11.768	33.62
6	1.635	4.67	13.403	38.3
7	1.546	4.42	14.95	42.71
8	1.436	4.1	16.386	46.82
9	1.4	4	17.785	50.81
10	1.36	3.89	19.146	54.7
11	1.326	3.79	20.471	58.49
12	1.206	3.45	21.677	61.93
13	1.179	3.37	22.856	65.3
14	1.084	3.1	23.941	68.4
15	1.045	2.99	24.985	71.39
16	1.035	2.96	26.021	74.35

Table F-2. Correlation coefficients (factor loadings) between values of 35 environmental variables and 16 principal components. Variables with the highest loadings are shown in bold face and grouped together. Variables from each grouping that were subsequently selected for further analysis are shaded in gray.

Groups	Variable	Factor															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Moderately Well Drained Soil	-0.87 ^A	0.03	-0.02	0.01	0.03	0.03	-0.03	-0.02	0.02	0.06	0	0.11	0.05	0.34	0	0
	Well Drained Soil ^B	0.93 ^A	0.01	-0.09	-0.01	0.01	0.06	-0.03	-0.06	0.04	0	0.03	0.1	0.03	0.15	-0.05	0.05
2	No Deer Browse ^B	-0.01	-0.9 ^A	-0.01	-0.15	-0.05	-0.01	0.03	0.05	-0.03	0.04	0.05	0.01	-0.02	0.02	0	0.03
	Some Deer Browse	-0.03	0.9 ^A	0.03	0.13	0.09	0.01	-0.02	-0.07	0.03	-0.03	-0.03	-0.02	0.06	-0.01	0.01	-0.05
3	No Erosion ^B	-0.04	0.04	0.94 ^A	-0.09	0.06	0.01	0.04	0.04	0	0.04	-0.03	0.01	-0.03	-0.07	0.02	0.04
	Some Erosion	0.02	0	-0.94 ^A	0.07	-0.02	-0.03	0	0	-0.02	-0.01	0.04	-0.01	0.03	0.04	0.01	-0.02
4	No Deer Trails ^B	0.02	-0.11	0.08	-0.93 ^A	-0.04	-0.01	-0.01	0.02	-0.04	0.04	-0.03	0.01	0.02	0.06	0.01	-0.03
	Some Deer Trails	0	0.14	-0.07	0.93 ^A	0	0.01	-0.03	0.03	0.04	-0.03	0.03	0.04	0.01	-0.04	0.02	0.01
5	No Human Disturbance ^B	0.03	-0.06	-0.07	-0.01	-0.89 ^A	-0.01	-0.07	0.03	0.18	-0.05	0.04	-0.01	0.01	0.02	0	-0.02
	Some Human Disturbance	0.01	0.12	0.01	0.04	0.82 ^A	0.02	-0.04	0.11	0.1	-0.01	-0.11	0.08	0.01	0.08	0.11	0.12
6	IERAT 2 ^B	-0.03	0.01	-0.04	-0.02	-0.05	-0.9 ^A	0.01	-0.2	0.04	0.01	0.03	0.06	0.02	0	0.04	0.11
	IERAT 4	0.02	0.11	0.06	-0.02	-0.15	0.51 ^A	-0.01	-0.5	0.07	-0.05	0	0.24	0.16	-0.07	0.25	0.17
7	Oak-Dominated Forest ^B	-0.03	0.05	-0.05	0.01	-0.05	0.01	-0.92 ^A	-0.02	0.06	-0.04	0.01	0.03	0.05	0.16	-0.15	-0.04
	Beech - Maple Glaciated Forest	-0.1	0.24	-0.27	-0.26	-0.35	-0.02	0.48 ^A	0.2	0.09	-0.04	-0.07	0.2	-0.02	0.21	-0.16	0.12
	Herbaceous Field	-0.21	-0.16	0.17	0.13	0.37	0	0.4 ^A	-0.18	0.15	-0.17	0.13	-0.13	0.17	0.14	-0.32	-0.34
8	IERAT 3 ^B	-0.04	-0.12	0.06	0.01	0.02	0.23	0.03	0.85 ^A	0.06	0.04	-0.01	0.03	0.09	-0.01	0.02	-0.05
	Distance_Trail ^B	-0.05	0.15	0	0.06	-0.17	-0.01	0.08	0.36 ^A	-0.32	-0.32	0.09	0	0.07	0.1	0.04	0.28

^A Variables with the highest loadings, shown in bold text.

^B Variables from each grouping that were subsequently selected for further analysis, highlighted in gray.

Table F-2 (continued). Correlation coefficients (factor loadings) between values of 35 environmental variables and 16 principal components. Variables with the highest loadings are shown in bold face and grouped together. Variables from each grouping that were subsequently selected for further analysis are shaded in gray.

Groups	Variable	Factor															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
9	Developed ^B	-0.05	-0.06	-0.03	-0.11	0.12	0.04	0.03	-0.04	-0.86 ^A	0.04	0	0.03	0.02	-0.09	-0.03	-0.02
	Dominant Species Richness ^B	-0.21	0.19	-0.3	-0.25	0.11	0.15	-0.18	0.07	0.38 ^A	0.1	-0.08	0.13	-0.05	-0.27	-0.05	0.1
10	Distance_Stream	0.03	-0.09	-0.01	0.18	-0.09	0.15	0.12	-0.24	-0.02	-0.66 ^A	0.02	0.05	0.1	-0.01	-0.08	-0.02
	Slope ^B	0.06	0.14	-0.07	0.02	0.02	-0.06	-0.11	0.05	0.05	-0.75 ^A	0.03	-0.02	-0.09	0.02	-0.01	0.05
	Distance_Road	-0.05	0.26	-0.07	-0.08	-0.01	-0.03	-0.14	0.16	0.12	-0.41	-0.13	-0.09	-0.04	0.18	-0.09	-0.08
11	Distance_Spring	0.06	-0.13	-0.09	0.11	-0.06	-0.04	-0.02	-0.04	0.05	-0.05	0.85 ^A	0.04	-0.02	-0.09	-0.07	-0.11
	Distance_Outcrop ^B	-0.02	0.03	0	-0.02	-0.06	0.01	0.01	0.03	-0.04	0.02	0.91 ^A	-0.02	0	0.02	0.03	0.05
12	Somewhat Poorly Drained Soil	0.07	-0.07	0.01	-0.08	0.01	-0.04	0.01	0.17	0.03	-0.18	-0.12	-0.59 ^A	0.12	-0.1	0.33	-0.03
	Successional Conifer Plantation Forest ^B	-0.06	0.11	-0.03	-0.01	-0.11	0.07	0.04	-0.05	0.04	0.07	0.04	-0.74 ^A	-0.01	0.02	-0.07	0.11
13	Very Poorly Drained Soil	0.01	-0.11	0.06	0.07	-0.05	-0.05	0.04	0	0.03	-0.22	0.01	0.08	-0.68 ^A	-0.04	0.09	0.05
	Wetland ^B	0	-0.02	0.08	-0.03	0.04	-0.01	0.07	-0.05	0.06	0.09	0.01	0.02	-0.73 ^A	-0.04	-0.02	-0.07
	IERAT 1 ^B	0.04	-0.09	-0.09	-0.06	0	0.18	-0.08	-0.15	-0.26	0.17	0.02	-0.36	-0.46 ^A	0.08	-0.3	-0.09
14	Invasive Species Richness ^B	0.09	0.22	0.04	0.08	0.09	0.36	0.05	-0.2	-0.03	0.08	0.03	-0.14	-0.06	-0.59 ^A	0.19	0.24
	Invasive Species Cover	0.19	-0.14	0.12	0.14	0.11	0.21	0.26	-0.12	-0.04	0.05	0.09	-0.07	-0.19	-0.52 ^A	0.17	0.33
	Poorly Drained Soil	-0.02	0.03	0.09	0.05	-0.09	-0.13	0.06	0.06	-0.1	-0.05	0.04	0.05	0.02	-0.78 ^A	-0.14	-0.17
	Floodplain Forest ^B	0.43	-0.08	0.12	0.15	-0.11	0.02	0.17	0.1	0.06	0.14	-0.02	0.06	0.03	-0.57 ^A	-0.14	-0.05
15	Successional Mixed Hardwood Forest ^B	-0.08	0	0.02	0.03	0.09	0.01	0.14	-0.03	0.03	0.05	-0.01	-0.02	0	0.07	0.88 ^A	-0.09
16	Successional shrub/black locust ^B	0.04	-0.12	0.08	0.06	0.13	-0.12	0.06	-0.08	0.05	-0.03	-0.06	-0.07	0.06	0.04	-0.13	0.8 ^A

^A Variables with the highest loadings, shown in bold text.

^B Variables from each grouping that were subsequently selected for further analysis, highlighted in gray.

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