National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Sentinel Wetlands in Cuyahoga Valley National Park

I. Ecological Characterization and Management Insights, 2008–2018

Natural Resource Report NPS/HTLN/NRR—2023/2494





ON THIS PAGE
Aerial view of Vegetation Index of Biotic Integrity plot at Stumpy Basin reference site.
Photography by NPS/DOUG MARCUM

ON THE COVER
Towpath Trail Boardwalk at Stumpy Basin
Photography by NPS/DOUG MARCUM

Sentinel Wetlands in Cuyahoga Valley National Park

I. Ecological Characterization and Management Insights, 2008–2018

Natural Resource Report NPS/HTLN/NRR—2023/2494

Sonia Bingham,[1] Craig Young[2]

[1]National Park Service
Heartland Inventory and Monitoring Network
Cuyahoga Valley National Park
15610 Vaughn Road
Brecksville, OH 44141

[2]National Park Service
Heartland Inventory and Monitoring Network
Wilson's Creek National Battlefield
5242 S. State Hwy ZZ
Republic, MO 65738

Editing and Design by
Tani Hubbard

National Park Service &
Northern Rockies Conservation Cooperative
12661 E. Broadway Blvd.
Tucson, AZ 85748

January 2023

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate comprehensive information and analysis about natural resources and related topics concerning lands managed by the National Park Service. The series supports the advancement of science, informed decision-making, and the achievement of the National Park Service mission. The series also provides a forum for presenting more lengthy results that may not be accepted by publications with page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible and technically accurate.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from the Heartland Inventory and Monitoring Network website, and the Natural Resource Publications Management website. If you have difficulty accessing information in this publication, particularly if using assistive technology, please email irma@nps.gov.

Please cite this publication as:

Bingham, S., and C. Young. 2023. Sentinel wetlands in Cuyahoga Valley National Park: I. Ecological characterization and management insights, 2008–2018. Natural Resource Report NPS/HTLN/NRR—2023/2494. National Park Service, Fort Collins, Colorado. https://doi.org/10.36967/2296885.

NPS 644/187453, January 2023

Contents

Page

Figures v
Tables v
Executive Summary vi
Acknowledgments vii
Introduction 1
Methods 3
Evaluation Metrics 4
Ohio Rapid Assessment Method 4
Vegetation Index of Biotic Integrity 4
Floristic Quality Assessment Index 4
Percent Sensitive Species 5
Percent Invasive Graminoids 5
Species Richness 5
Ecological Characterization of Sentinel Wetlands 6
Reference Wetlands 6
Boston Mills (683) 6
Langes (124) 6
Virginia Kendall Lake (241) 8
Columbia Run (554) 8
Stumpy Basin (526) 9
Snowville (398) 11
Bath (1427) 11
Fitzwater (970) 12
Rare Habitat-Wetlands of Management Concern 12
Beaver Marsh 12
Stumpy Basin 14
Virginia Kendall Lake 15
Restoration-Wetlands of Management Concern 17
Fawn Pond 17
Stanford Run 18
Pleasant Valley 20

Contents (continued)

Page

Mitigation-Wetlands of Management Concern . . . 21
Krejci . . . 21
Rockside . . . 23
Brookside . . . 24
Discussion . . . 25
VIBI Scores Across Large Wetland Complexes . . . 25
ORAM and VIBI Discrepancies . . . 25
Vernal Pools . . . 25
How Do Cuyahoga Valley NP Reference Wetlands Score in Comparison to Established Ranges? . . . 25
How are Cuyahoga Valley NP Mitigation Wetlands Faring Over Time? . . . 26
Status of Park-selected Restoration Wetlands . . . 26
What Are We Seeing With Invasive Species in Sentinel Wetlands? Should We Control Them? . . . 27
Literature Cited . . . 28
Appendix A. Evaluation Metric Summary . . . 30

Figures

Page

Figure 1. Distribution of sentinel wetlands (wetlands of management concern and reference wetlands) across Cuyahoga Valley National Park. . . . 2

Figure 2. The preferred sampling array for (A) emergent, aquatic bed, and scrub-shrub wetlands and (B) forested wetlands, and (C) an example alternative sampling array for situations where the preferred array was not possible because of wetland shape, size, or vegetative composition. . . . 4

Figure 3. Reference wetlands (Boston Mills 683, Langes 124, VK Lake 241VK3, and Columbia 554) . . . 7

Figure 4. Reference wetlands (Stumpy 527, Snowville 398, Bath 1427, and Fitzwater 970) . . . 10

Figure 5. Beaver Marsh plot locations . . . 13

Figure 6. Stumpy Basin plot locations . . . 15

Figure 7. Virginia Kendall Lake plot locations . . . 16

Figure 8. Fawn Pond plot locations . . . 18

Figure 9. Stanford Run plot locations . . . 19

Figure 10. Pleasant Valley plot locations . . . 20

Figure 11. Krejci plot locations . . . 22

Figure12. Rockside plot locations . . . 23

Tables

Page

Table A1. Ohio Rapid Assessment Method (ORAM) scores and antidegradation categories at all sentinel wetlands . . . 30

Table A2. Metric scores at sentinel wetlands for the baseline surveys between 2008 and 2015 and the follow up survey in 2018 . . . 31

Executive Summary

Sentinel wetlands at Cuyahoga Valley National Park (NP) comprise a set of twenty important management areas and reference sites. These wetlands are monitored more closely than other wetlands in the wetlands monitoring program and are the focus of the volunteer monitoring program for water levels. We used the Ohio Rapid Assessment Method (ORAM) to evaluate habitat in the sentinel wetlands. A total of 37 long-term sample plots have been established within these wetlands to monitor biological condition over time using vegetation as an indicator. Vegetation is intensively surveyed using the Vegetation Index of Biotic Integrity (VIBI), where all plant species within the plot are identified to the lowest taxonomic level possible (genus or species). Sample plots were surveyed twice from 2008 to 2018 and the vegetation data were evaluated using five metrics: VIBI, Floristic Quality Assessment Index (FQAI), percent sensitive plant species, percent invasive graminoids, and species richness. These metrics are discussed for each location. This report also highlights relevant land use histories, common native plant species, and invasive species of concern at each wetland. This is the first report in a two-part series, designed to summarize the results from intensive vegetation surveys completed at sentinel wetlands in 2008–2018.

Boston Mills, Virginia Kendall Lake, Stumpy Basin, Columbia Run, and Beaver Marsh are all in excellent condition at one or more plots. They have unique habitats with some specialized plant species. Fawn Pond is in good condition at most plots and scores very high in comparison to other wetlands within the riverine mainstem hydrogeomorphic class.

Metric scores across mitigation wetlands were low. Two of the three wetlands (Brookside and Rockside) are not meeting the benchmarks originally established by the United States Army Corps of Engineers and Ohio Environmental Protection Agency. Krejci is still a young mitigation site and success will be determined over time. Park-supported invasive species control efforts will be crucial for long-term success of these sites and future mitigation/restoration projects.

The wetlands monitored because of proposed ecological restoration projects (Pleasant Valley, Stanford Run, and Fawn Pond) have extensive invasive plant communities. A stream restoration project was completed at Stanford Run in 2020, and we are currently documenting the water level and vegetative community changes. The other two sites should be re-evaluated for their feasibility and potential success and given an order of prioritization relative to the newer list of restoration sites. Cuyahoga Valley NP has added many new areas to their list of potential wetland restoration sites after these areas were selected, and there may be better opportunities available based on restoration goals at this point. Restoration goals should be based on the park's desired future conditions, and mitigation goals of outside partners may not always be in line with those.

The multiple VIBI plots dispersed throughout the large wetlands at Cuyahoga Valley NP detected and illuminated spatial patterns in condition. Many individual wetlands had a wide range of VIBI scores within their boundaries, sometimes reflecting localized disturbances, past modifications, and management actions. Most often, these large fluctuations in condition were linked to local invasive plant infestations. These infestations appear to be the most obvious and widespread threat to wetland ecosystems within the park, but also the most controllable threat. Some sensitive species are still present in some of the lowest scoring plots, which indicates that invasive plant species control efforts may pay off immediately with a resurgence of native communities. Invasive plant control at rare habitat sites would have large payoffs over time by protecting some of the park's most unique wetlands. Reference wetlands would also be good demonstration sites for park managers to try to maintain exemplary conditions through active management. Through this work, park managers can evaluate the feasibility, effectiveness, and scalability of management practices required to maintain wetland condition.

Acknowledgments

Kevin Skerl and Meg Plona were the resource managers at Cuyahoga Valley National Park who originally selected the park wetlands of management concern. Reference sites were selected by Heartland Inventory and Monitoring (I&M) Network staff following extensive habitat assessments during the earliest stages of the wetland monitoring program development process. Luke Biscan, Brandon Piper, and Doug Marcum assisted with vegetation surveys over the course of the two monitoring periods evaluated here. Doug Marcum has provided extensive field work and expertise throughout the entire implementation process.

Introduction

Cuyahoga Valley National Park (NP) resource managers selected a set of sentinel wetlands to be able to detect and address common management issues at these important sites. Sentinel wetlands are monitored more closely than other wetlands in the monitoring program (Bingham et al. 2016). The sentinel wetland set includes eight reference wetlands and eight wetlands of management concern complexes (composed of 12 individual wetlands; Figure 1). Reference wetlands formed a natural grouping that reflected our perceptions of high quality, least-disturbed examples of a particular hydrogeomorphic (HGM) class, potentially representing the "best attainable condition" (Stoddard et al. 2006). We classified wetlands of management concern into three groups based on park concerns: rare habitat wetlands, restoration wetlands, and mitigation wetlands. These types reflect park specific concerns around wetland management, including suitability as rare habitat; ecological restoration projects, often to improve stormwater management function; or sites used as compensatory mitigation. The wetlands of management concern are large wetland complexes that require multiple plots for adequate characterization (Bingham et al. 2016), bringing the total number of sentinel wetland plots to 37.

This is the first report in a two-part series designed to summarize the results from intensive vegetation surveys completed at sentinel wetlands in 2008–2018. We use a site-by-site approach to characterize the conditions in each wetland, which will provide baseline reference information for other reports and site-specific projects. To complete this characterization, we used six evaluation metrics, field observations, and documentation of site histories.



Fawn Pond Swamp, Cuyahoga Valley National Park, OH. NPS/SONIA BINGHAM

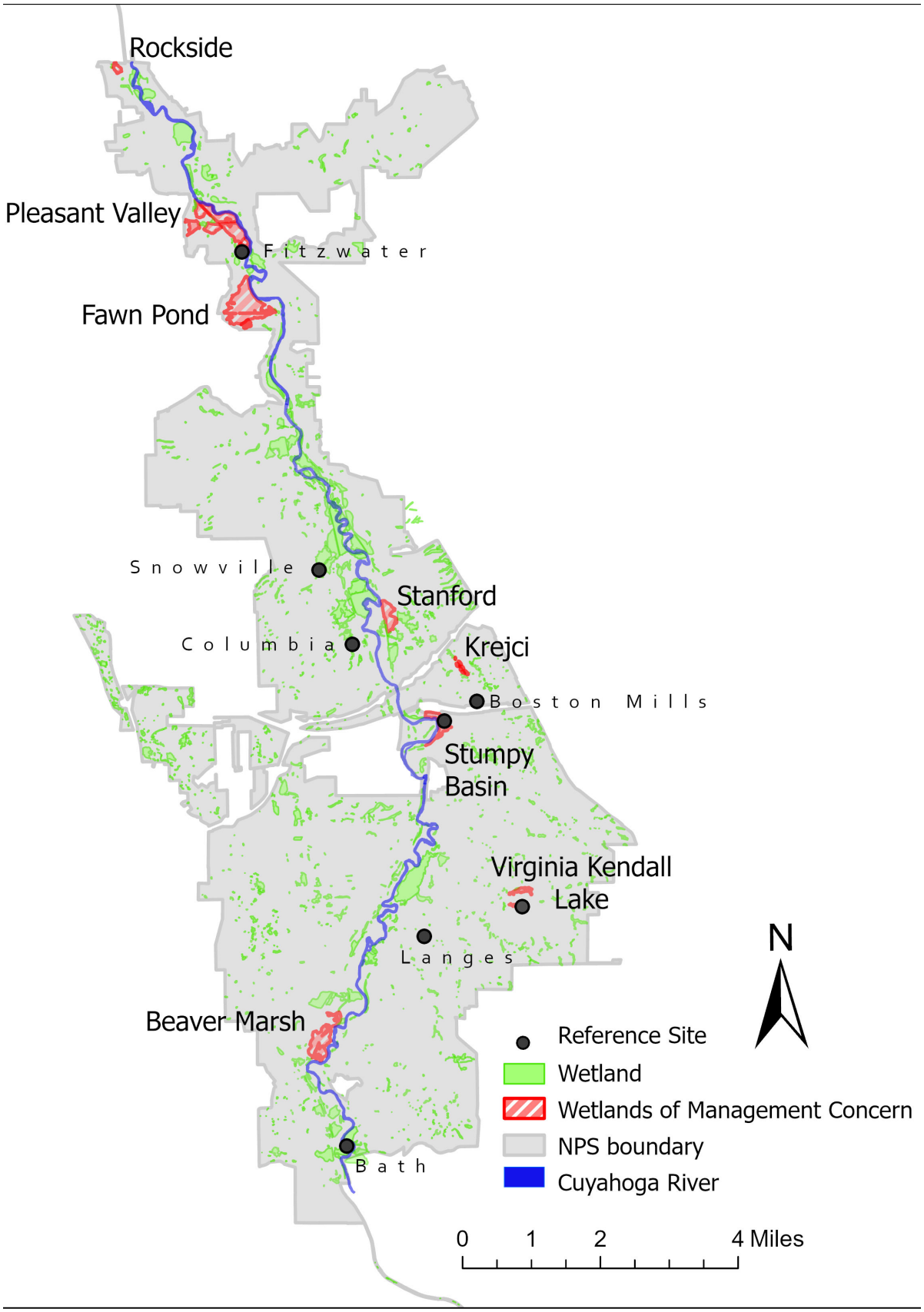


Figure 1. Distribution of sentinel wetlands (wetlands of management concern and reference wetlands) across Cuyahoga Valley National Park, OH.

Methods

We completed a rapid assessment once for each wetland after the initial wetland boundary delineation was completed. The observer walked the perimeter of the wetland categorizing and scoring six metrics (Mack 2001) to calculate an Ohio Rapid Assessment Method (ORAM) score.

After the delineations were complete, we selected and established permanent sample plot locations and completed the intensive assessments (Figure 1). Vegetation was surveyed comprehensively within sample plots to characterize the condition of each unique hydrogeomorphic (HGM) class/vegetation type within the wetland (Mack and Gara 2015) using the Vegetation Index of Biotic Integrity (VIBI). Sample plots consisted of one to ten 10-m × 10-m squares (i.e., 100 m^2) referred to as modules (Figure 2). The standard plot size was four modules, with ten modules used whenever possible in forested wetlands (Bingham et al. 2016). Plots were sometimes smaller because of wetland size constraints.

We used a two-person team to sample vegetation between June 15 and October 15 when key plant identification characteristics were most visible since VIBI calculations require highly accurate identification of plants to species level. The cover of all vascular plant species, the density and identity of woody stems less than 3 ft tall, the diameter and identity of all woody stems greater than 3 ft tall, and biomass (for emergent wetlands only) were measured and recorded separately within each 100-m^2 module. Baseline surveys were completed between June 21, 2008, and September 2, 2015, during the plot setup and establishment phase. Thirty-six of the plots were resurveyed between June 27, 2018, and September 15, 2018, and one plot was resurveyed the following year (1079RS2) on September 17, 2019, because it was part of an additional sample set.



Lock 26 at the Beaver Marsh, Cuyahoga Valley National Park, OH. NPS/SONIA BINGHAM

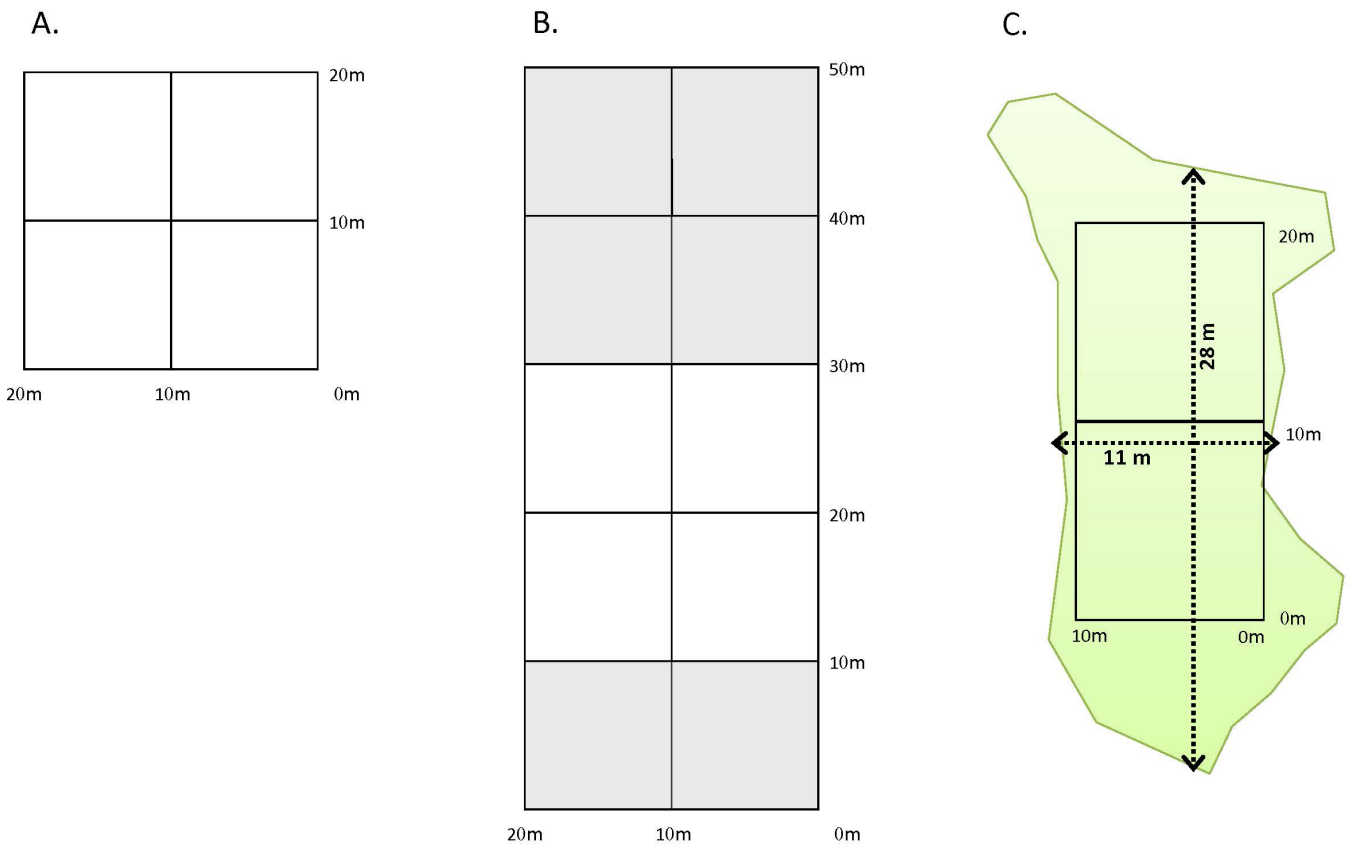


Figure 2. The preferred sampling array for (A) emergent, aquatic bed, and scrub-shrub wetlands and (B) forested wetlands, and (C) an example alternative sampling array for situations where the preferred array was not possible because of wetland shape, size, or vegetative composition.

Evaluation Metrics

Each evaluation metric is described in detail below. A complete table displaying the values of evaluation metrics is shown in Appendix A.

Ohio Rapid Assessment Method

The Ohio Rapid Assessment Method (ORAM) is derived from the rapidly assessed method (Bingham et al. 2016), which allows general inferences about the overall ecological health of wetlands. The ORAM is calculated based on six categorical metrics that characterize wetland condition: (1) wetland size; (2) buffers and surrounding land use; (3) hydrology; (4) habitat alteration and development; (5) special wetland communities; and (6) vegetation, interspersion and microtopography. The composite score of 16 factors yields a number between 0 and 100. For the purposes of this report, we interpret the ORAM scores for all wetlands as follows: 0.0–29.9 = poor; 30.0–44.9 = fair; 46.0–59.9 = good; and 60.0–100.0 = excellent. See Mack (2001) for additional details and specifics on interpretation.

Vegetation Index of Biotic Integrity

The Vegetation Index of Biotic Integrity (VIBI) score is derived from the intensively assessed method (Bingham et al. 2016). It is a multi-metric composite index, based on detailed taxonomic identification of plants, that indicates wetland condition. The VIBI is calculated by summing 10 metric scores that are selected based on the wetlands dominant plant community type. The combined metrics yield a score between 0 and 100. For the purposes of this report, we interpret the VIBI scores for all wetlands as follows: 0–29 = poor; 30–59 = fair; 60–73 = good; and 74–100 = excellent. See Mack (2001) and Mack and Gara (2015) for additional details and specifics on interpretation.

Floristic Quality Assessment Index

The Floristic Quality Assessment Index (FQAI) is one of the metrics calculated using the VIBI. It is a weighted richness metric that assigns a Coefficient of Conservatism (C of C) from 0 to 10 to all species present in the VIBI plot. Higher FQAI scores

indicate there are more native plants in the plot with specific ecological requirements (Andreas et al. 2004). FQAI scores between 1 and 19 suggest low vegetative quality; scores between 20 and 35 indicate high vegetative quality, and scores above 35 indicate "natural area" quality (Swink and Wilhelm 1994).

Percent Sensitive Species

The percent sensitive species (% sensitive) metric is calculated using the VIBI. It assesses the relative abundance of high C of C species. The relative cover values of all species with C of C of 6 or higher are summed (Mack and Gara 2015). Standards are not available for interpreting this metric.

Percent Invasive Graminoids

The percent invasive graminoids (% invasive graminoids) metric is calculated using the VIBI. It assesses the relative abundance of selected aggressive graminoids in wetland communities: reed canary grass (*Phalaris arundinacea*), cattails (*Typha angustifolia*, *T. latifolia*, *T.* × *glauca*), and giant reed (*Phragmites australis*; Mack and Gara 2015). Japanese stiltgrass (*Microstegium vimineum*) is notably not included. Standards are not available for interpreting this metric.

Species Richness

Species richness is derived from the VIBI. It is the average number of species found within a 10-m × 10-m module in a VIBI plot (Mack and Gara 2015). Modules were averaged for the plot since plot sizes were often different.

Ecological Characterization of Sentinel Wetlands

In most cases only the most recent (2018) metric scores are discussed in the text. However, in some cases, it was more appropriate to highlight the highest or lowest values from the two sample years, rather than listing both values. If the highest or lowest scores are used, they are preceded with a greater than (>) or less than (<) sign. See Appendix A for all data referenced in this section.

Reference Wetlands

Boston Mills (683)

VIBI Score(s): 84 (2014), 81 (2018)
ORAM Score(s): 83 (2010)
HGM/Vegetation Type: depressional/swamp
Size: 1.6 acres

Boston Mills (683) was selected as a reference wetland given its remote location with a large, forested buffer and known importance for amphibian breeding as a vernal pool (Figure 3a). Boston Mills had *excellent* Vegetation Index of Biotic Integrity (VIBI) and Ohio Rapid Assessment Method (ORAM) scores and a very high percentage of sensitive species (>49%). The wetland is mostly surface water driven with nearly permanent inundation or saturation. The dominant vegetation consists of buttonbush (*Cephalanthus occidentalis*), brome-like sedge (*Carex bromoides*), and other sedges (*Carex* spp.), but also includes a swamp forest and emergent vegetation community component along the vernal pool margins with no documented invasive species at this time. The East Rim bike trail was opened in 2018, bringing visitation to an area that previously was largely inaccessible. Notable species that are unusual in Cuyahoga Valley NP wetlands include swamp cottonwood (*Populus heterophylla*) and weak stellate sedge (*Carex seorsa*). High scores on the Amphibian Index of Biotic Integrity (AmphIBI = 43, unpublished 2014 data) support the importance of this wetland for amphibian breeding.

Langes (124)

VIBI Score(s): 23 (2014), 25 (2018)
ORAM Score(s): 64 (2010)
HGM/Vegetation Type: depressional/swamp
Size: 0.3 acres

Langes (124) is another notable vernal pool with nearly permanent inundation (Figure 3b). Like Boston Mills, the wetland is in a remote location with a large, forested buffer; and is of known importance as an amphibian breeding site. The site includes a dominant buttonbush scrub-shrub community and a floating mat of emergent vegetation. There has been some debate about the land use history and whether it was ever modified in the past. While the AmphIBI score (47, unpublished 2014 data) was high, the wetland surprisingly scored within the *poor* range on the VIBI because of general low species richness (13) and lack of sensitive species (0%). The steep slopes and smaller size of this wetland deter the development of more wetland plants along the fringe of the pool, resulting in a low score for an otherwise remarkable wetland. This may be the case for other depressional wetlands in the park as well; VIBI scores should be used cautiously when applied to these important habitats.



Skunk cabbage (*Symplocarpus foetidus*) bloom, Cuyahoga Valley National Park, OH. NPS/SONIA BINGHAM

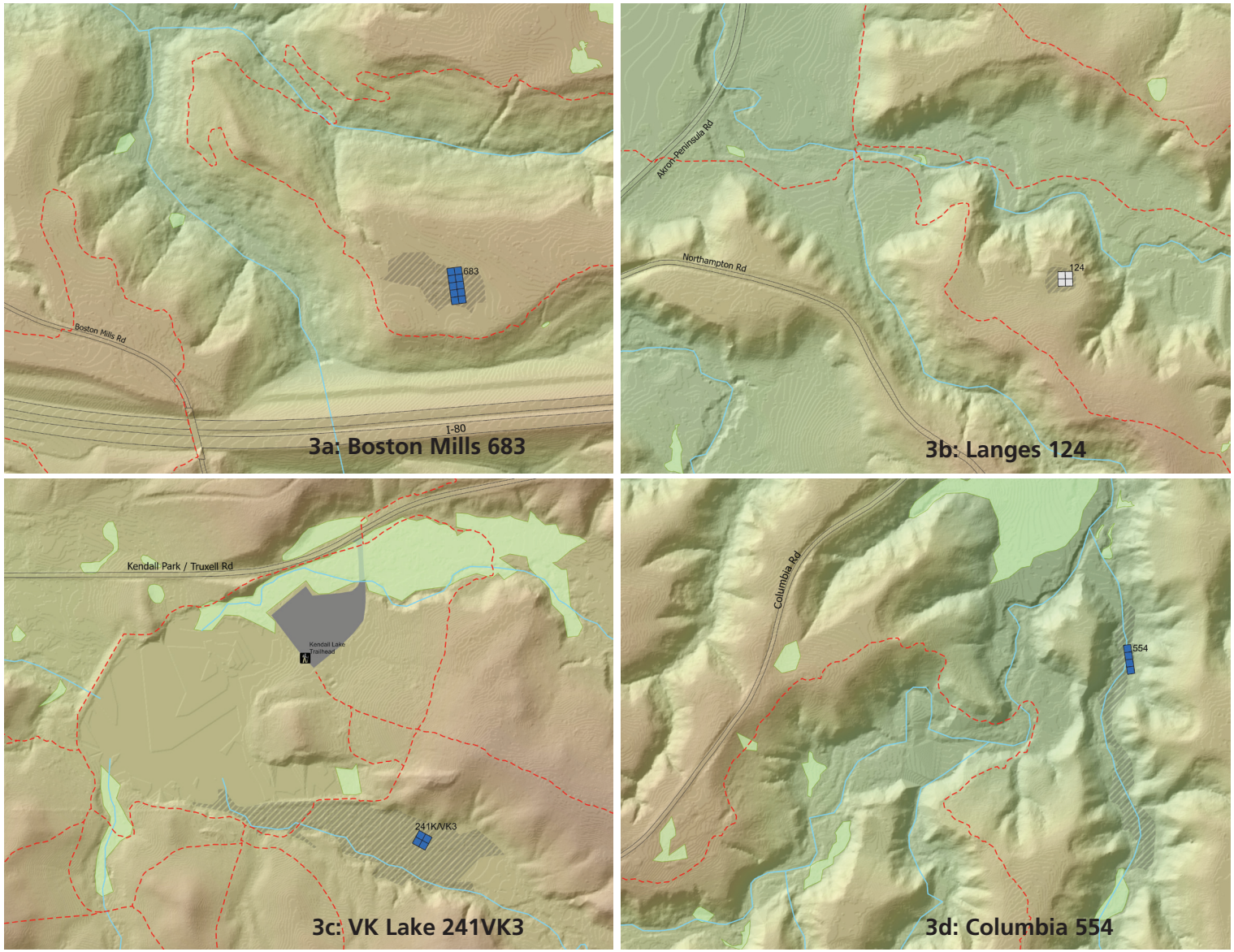


Figure 3. Reference wetlands (Boston Mills 683, Langes 124, VK Lake 241VK3, and Columbia 554). Plots are color coded by Vegetation Index of Biotic Integrity (VIBI; dark blue = excellent, light blue = good, yellow = fair, white = poor). Highlighted wetlands are striped, and all others are light green. Parking lots are dark solid gray, trails are dashed red lines and trailheads (if nearby) are labeled with a hiker icon and text. The Cuyahoga River and other tributaries are light blue. Most wetlands are set at scale 1:3,000, except Stumpy Basin and Bath, which are 1:4,000.



Sedge meadow at Stumpy Basin, Cuyahoga Valley National Park, OH. NPS/SONIA BINGHAM

Virginia Kendall Lake (241)

VIBI Score(s): 84 (2009), 84 (2018)
ORAM Score(s): 70.5 (2011)
HGM/Vegetation Type: riverine headwater/marsh
Size: 5.7 acres

Virginia Kendall Lake (241K/VK3) had a VIBI score within the *excellen*t range during 2009 and 2018. The groundwater table is stable all year round with an active seep that is always saturated near or above the surface and water tables usually around 5 to 10 cm (unpublished 2019–2021 data). Like most slope wetlands, Virginia Kendall Lake is groundwater dependent and protected by its mid-slope landscape position (Figure 3c). The vegetation community included a high percentage of sensitive species (>19.3%), and high Floristic Quality Assessment Index (FQAI) scores (>20) for both years. Species with high Coefficients of Conservatism (6 or greater) were found in the herbaceous layer (skunk cabbage [*Symplocarpus foetidus*], brome-like sedge, and marsh fern [*Thelypteris palustris]*) and in the shrub layer (willows [*Salix* spp.] and dogwoods [*Cornus* spp.]). Invasive graminoids were present but in relatively low cover (<3.4%).

Columbia Run (554)

VIBI Score(s): 87 (2014), 91 (2018)
ORAM Score(s): 61 (2010)
HGM/Vegetation Type: slope/wet meadow
Size: 2.1 acres

Columbia Run (554), like Virginia Kendall Lake, also had *excellent* VIBI scores in 2014 and 2018. Like most slope wetlands, Columbia Run is groundwater dependent and protected by its mid-slope landscape position (Figure 3d). Groundwater seeps provide a nearly permanent water source to the wetland, and it is saturated all year round. The vegetation community had the highest ranked FQAI score (33.4), a high percentage of sensitive species (>21%), and extraordinarily high species richness (>53.8). Skunk cabbage and clearweed (*Pilea pumila*) were dominant in the understory. Trees growing in the canopy within the wetland limits were sparse, but ironwood (*Carpinus caroliniana*) was common in the understory. No invasive graminoids were detected during the surveys.

Stumpy Basin (526)

VIBI Score(s): 90 (2011), 64 (2018)
ORAM Score(s): 73.5 (2008)
HGM/Vegetation Type: riverine headwater/wet meadow
Size: 30.7 acres

The Stumpy Basin reference plot (526; Figure 4a) had the highest VIBI score of all plots in 2011. However, the VIBI score dropped from the *excellent* range (Category 3) to the *good* range in 2018 due to natural disturbances and invasive species colonization. We also documented declines in FQAI scores (decreased from 27.1 to 21.1) and percent sensitive species present (decreased from 40.4% to 28.2%) during that time. The vegetation is dominated by uncommon meadow species such as elliptic spikerush (*Eleocharis elliptica*) and swamp candles (*Lysimachia terrestris*) as well as other less common sedges, rushes (*Juncus* spp.), and bulrushes (*Scirpus* spp). The encroachment of glossy buckthorn (*Rhamnus frangula*) and giant reed are concerns here—as well as the movement of Japanese stiltgrass in this area. From 2018 to 2021, park staff began to control giant reed and Japanese stiltgrass to prevent spread into rare plant locations. With invasive plants controlled, we would expect a rebound in VIBI scores in 2023.

This wet meadow area within Stumpy Basin has been referred to as "Lake Plain Prairie," which receives regular surface water inundation from a primary headwater stream that meanders through it. Although buffered from adjacent developments by steep ravines, VIBI data confirm that Stumpy Basin is vulnerable to environmental disturbances, including stormwater. Natural erosion processes and sediment transport in this area are largely responsible for the development of the unique plant community, but also appeared responsible for the lower VIBI score in 2018. The wetland is highly dynamic with respect to sediment transport; vegetation communities appear to be in constant transition. Several feet of sand deposition were recorded in this location over a 10-year period of water level monitoring (unpublished 2009–2019 data). This disturbance also allows the seed of aggressive plants to cycle in from upstream and establish on the site. To maintain high quality riverine headwater wetlands, unnatural erosion and sedimentation should be controlled through stormwater management (e.g., forested buffers, stormwater basins, beaver dam analogs).



Alluvium at Stumpy reference site, Cuyahoga Valley National Park, OH. NPS/SONIA BINGHAM

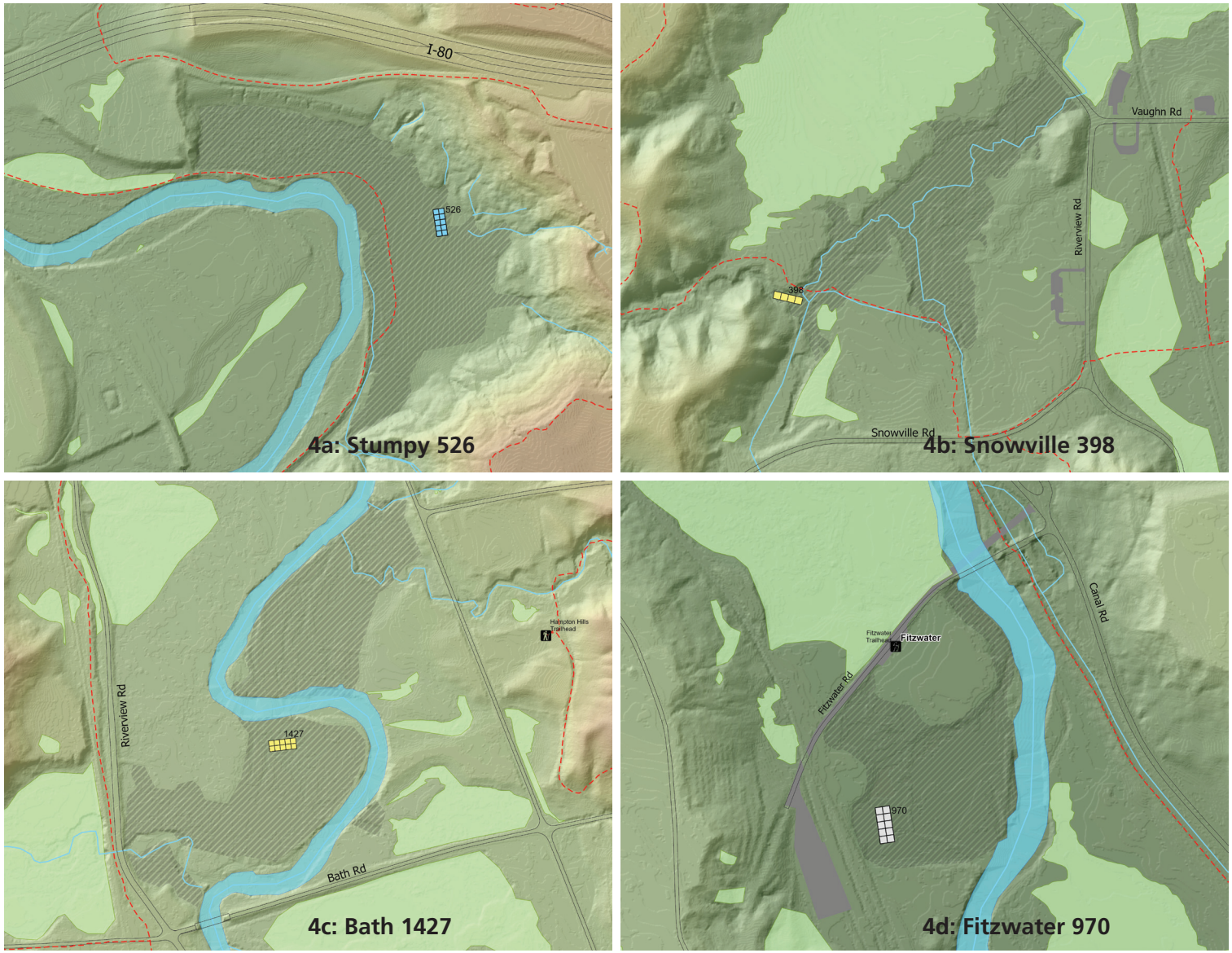


Figure 4. Reference wetlands (Stumpy 527, Snowville 398, Bath 1427, and Fitzwater 970). Plots are color coded by Vegetation Index of Biotic Integrity (VIBI; dark blue = excellent, light blue = good, yellow = fair, white = poor). Highlighted wetlands are striped, and all others are light green. Parking lots are dark solid gray, trails are dashed red lines and trailheads (if nearby) are labeled with a hiker icon and text. The Cuyahoga River and other tributaries are light blue. Most wetlands are set at scale 1:3,000, except Stumpy Basin and Bath, which are 1:4,000.



Erosion and fill at Stumpy Basin, Cuyahoga Valley National Park, OH. NPS/SONIA BINGHAM

Snowville (398)

VIBI Score(s): 58 (2014), 54 (2018)
ORAM Score(s): 61.5 (2010)
HGM/Vegetation Type: riverine headwater/wet meadow
Size: 10.7 acres

Similar to Stumpy Basin, Snowville (398; Figure 4b) receives surface water inundation from a headwater stream. It was selected as a reference site because the plant community appeared relatively diverse and intact at the time of selection (2010) and the ORAM score was within the *excellent* range. However, the VIBI score was within the *fair* range and scores appear to be declining. The stream is larger in drainage area and is affected by other pollution sources such as stormwater runoff. The documented plant species are mostly those tolerant of sediment movement and accretion. The FQAI scores were above average (15.5–18.2), although not of high quality, and the percent sensitive species cover was low (<2.1%). The plant community is a wet meadow, dominated by common horsetail (*Equisetum arvense*), rice cutgrass (*Leersia oryzoides*), spotted touch-me-not (*Impatiens capensis*), and asters (*Symphyotrichum* spp.). Increases in giant reed and Japanese stiltgrass were responsible for the decrease in VIBI scores between 2014 and 2018.

Bath (1427)

VIBI Score(s): 36 (2014), 40 (2018)
ORAM Score(s): 67 (2010)
HGM/Vegetation Type: riverine mainstem/swamp
Size: 35.0 acres

Bath (1427; Figure 4c) directly shares the human disturbance history of the Cuyahoga River. It has a lateral connection with and is occasionally flooded by the Cuyahoga River, its primary water source. This area was selected as a reference site due to its mature canopy. The plot is located within a wetland system that scored within the *excellent* range on the ORAM in 2010. However, the VIBI score was within the *fair* range during both surveys. The most recent FQAI scores at Bath (16.6 in 2018) were slightly above average across all sentinel wetlands (14.9), but low in comparison to the average at the eight reference wetlands (20.6; Bingham and Young 2023). The percent sensitive species cover was low both years (<0.5%). Woodlands in the area were previously classified as a cottonwood-sycamore floodplain forest (Hop et al. 2013) but in this plot location, the community type is similar to the silver maple-elm forest. In 2018, there were 16 large trees that measured over 40 cm in diameter within the VIBI plot. Most of those mature trees were silver maple (*Acer saccharinum*) and cottonwood

(*Populus deltoides*), although an American elm (*Ulmus americana*) also measured in that size class. In 2018 and 2019, park staff removed common privet (*Ligustrum vulgare*) in the area adjacent to the plot. Understory dominants included jumpseed (*Persicaria virginiana*) and poison ivy (*Toxicodendron radicans*). There was a unique sedge species not found elsewhere in the park here—Muskingum sedge (*Carex muskingumensis*). Privet, multiflora rose (*Rosa multiflora*), and Japanese knotweed (*Reynoutria japonica*) are adjacent to and encroaching into this area.

Fitzwater (970)

VIBI Score(s): 23 (2014), 29 (2018)
ORAM Score(s): 58 (2010)
HGM/Vegetation Type: riverine mainstem/swamp
Size: 12.8 acres

Fitzwater (970; Figure 4d), like most riverine mainstem wetlands, directly shares the human disturbance history of the Cuyahoga River. Fitzwater scored within the *good* range on the ORAM, but in the *poor* range on the VIBI in both survey years. The FQAI scores (15 and 17.8) were similar to those at Bath. The percent sensitive species cover was low (0% and 1.1%). The wetland is located within an area classified as silver maple-elm-forest within the Pleasant Valley Wetland Complex. This wetland complex was highly modified in the past and modifications nearby are evident. It is also adjacent to the Fitzwater train yard. However, the area is an active floodplain along the Cuyahoga River with more large diameter canopy trees in the swamp forest than most other floodplain wetlands we observed in the north end of the park. Nearly a dozen cottonwood (*Populus deltoides*) and silver maple measured over 40 cm in diameter. Box elder (*Acer negundo*) were common in the subcanopy. Understory dominants included blunt broom sedge (*Carex tribuloides*), moneywort (*Lysimachia nummularia*), wild rye (*Elymus* sp.), and the invasive graminoid, reed canary grass. Invasive graminoids accounted for between 8.8% and 9.8% of the VIBI plot cover between both years.

Rare Habitat-Wetlands of Management Concern

Beaver Marsh

VIBI Score(s):
BM2 = 71 (2011), 71(2018)
BM3 = 81 (2011), 77 (2018)
BM4 = 33 (2011), 43 (2018)
BM5 = 71 (2011), 56 (2018)
BM6 = 57 (2011), 74 (2018)
ORAM Score(s): 88 (2008)
HGM/Vegetation Type: riverine mainstem, depressional, slope/marsh, forest and shrub swamp, wet meadow
Size: 67.9 acres

The Beaver Marsh is one of the most popular destinations in the park and is designated as a "watchable wildlife area" in the State of Ohio. The area offers excellent opportunities to view a unique



Beaver Marsh, Cuyahoga Valley National Park, OH. NPS/DENNY REISER

and extensive wetland ecosystem along the towpath. The marshland was once a dairy farm and an auto repair shop that rebounded quickly upon naturalization, with assistance from beavers (*Castor canadensis*). Beaver Marsh is an approximately 70-acre wetland complex near the south end of Cuyahoga Valley NP that is fed by a tributary from the west (across Howe Meadow), groundwater seeps, inputs from the O&E Canal near Lock 26, and occasional flooding from the Cuyahoga River. Beaver activity further impounds the water, creating a variety of depths and associated plant communities across the marsh. The mix of swamp, marsh, wet meadow, and water sources contributes to an excellent ORAM score for Beaver Marsh. This wetland has made an extraordinary recovery from past land use modifications.

Five VIBI plots are spread across representative areas to evaluate each HGM/plant community combination (Figure 5). A plot was not placed in the open water portion of the marsh because sampling could not be done safely and efficiently. Two community types, represented by plots BM3 and BM6, were in *excellent* condition, while the swamp forest (BM4) and a plot adjacent to the gasoline easement (BM5) were in *fair* condition. The lower VIBI scores in these areas reflected an extensive understory population of the invasive reed canary grass. We also recorded substantially increased coverage of giant reed in the vicinity of the powerline corridor at Oxbow Pond (BM3) and areas adjacent to plots BM5 and BM6. The Oxbow Pond area (BM3) was the highest scoring plot in 2011 at Beaver Marsh but dropped in scoring by 2018 and will continue to degrade over time without intervention. One stand of giant reed in the deep-water marsh was controlled in 2019. The vegetation quality at plot BM2 was *good* but scores would likely be much higher without the cattails. The area around plot BM2 is likely affected by roadside runoff and land use practices to the west of Riverview Road. Common native marsh species

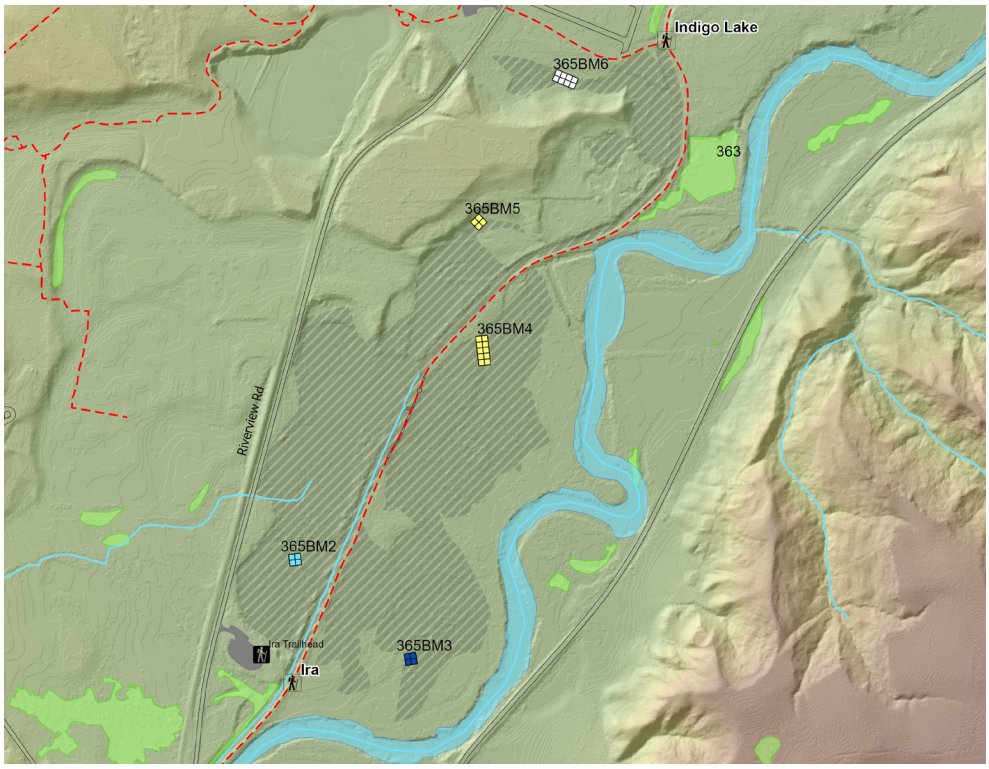


Figure 5. Beaver Marsh plot locations. Plots are color coded by Vegetation Index of Biotic Integrity (VIBI; dark blue = excellent, light blue = good, yellow = fair, white = poor). Highlighted wetlands are striped, and all others are light green. Parking lots are dark solid gray, trails are dashed red lines, and trailheads (if nearby) are labeled with a hiker icon and text. The Cuyahoga River and other tributaries are light blue. Scale = 1:6,000.

include swamp goldenrod (*Solidago patula*), skunk cabbage, swamp milkweed (*Asclepias incarnata*), lake sedge (*Carex lacustris*), crested sedge (*Carex cristatella*), rice cutgrass, Allegheny monkeyflower (*Mimulus ringens*), buttonbush, hemp dogbane (*Apocynum cannabinum*), green arrow arum (*Peltandra virginica*), clearweed, water purslane (*Ludwigia palustris*), and broadfruit bur-reed (*Sparganium eurycarpum*).

Stumpy Basin

VIBI Score(s):
SB1 = 46 (2011), 47 (2018)
SB2 = 40 (2011), 54 (2018)
SB3 = 51 (2011), 50 (2018)
526 (reference) = 90 (2011), 64 (2018)
ORAM Score(s): 73.5 (2008)
HGM/Vegetation Type: riverine mainstem, riverine headwater, depressional, slope/emergent marsh, forest and shrub swamp, wet meadow
Size: 30.7 acres

Stumpy Basin is a regionally distinctive botanical area known by many local plant enthusiasts for its unique plant communities and rare species. The wetland originates at Old Lonesome lock, which was built as part of the Ohio and Erie Canal around 1830 and ends at a large man-made basin that was once a turning basin for canal boats and ice harvesting (Bishop and Bishop 1945). Ice from the pond was cut into blocks, stored in ice houses, and transported to Cleveland before spring melt. Large diameter tree stumps (hence the name, Stumpy Basin) were still visible above the surface water of the basin in the early 1900s, suggesting that this area may have previously been a large swamp forest. Today, the towpath transects a portion of Stumpy Basin as an elevated wooden boardwalk.

The wetland encompasses approximately 30 acres of mostly wet meadow. Five small headwater streams carry heavy alluvial bedload from the surrounding slopes into the wetland and create a sand prairie habitat that is quite unusual for the region. Groundwater seeps at the base of the valley walls and occasional flooding by the Cuyahoga River also feed the site. The alluvium and seed sources deposited from the headwater streams create continuously changing conditions within the wetland. Natural erosion processes in this area are largely responsible for the development of the unique plant community.

There are four VIBI plots within the Stumpy Basin wetland, including the reference plot (Figure 6). The plots capture the more natural areas of Stumpy Basin rather than areas within the canal and associated features. However, there is still a wide range of disturbance and condition within its boundaries. The reference plot 526 is in an area defined by the sand deposition as "Lake Plain Prairie." It had the highest VIBI scores of all Stumpy Basin plots in both years, but scores declined from 2011 to 2018. In 2018, fresh alluvium from headwater streams was deposited over much of the previously established vegetation, which appeared responsible for the decline in the VIBI score. VIBI scores at the other plots (SB1, SB2, and SB3) fell within the *fair* range during both survey years. Lower scores in these areas likely reflect a number of historical impairments related to the Ohio & Erie Canal. Giant reed and Japanese stiltgrass are the most threatening invasive plants that are establishing in the area, but there are also concerns about glossy buckthorn populations along the boardwalk. The plant community at plot SB1 was almost completely overtaken by giant reed before control efforts began in 2018. Annual monitoring and removal of these invasive plants will help the plant communities rebound in the future. Highlighted native plants seen across Stumpy Basin include awlfruit sedge (*Carex stipata*), crested sedge, gray dogwood (*Cornus racemosa*), elliptic spikerush, common horsetail, Indiangrass (*Sorghastrum nutans*), and less common rushes, such as tapertip rush (*Juncus acuminatus*) and smallhead rush (*Juncus brachycephalus*). Although not surveyed in any of the VIBI plots, this is the only wetland in the park with a natural stand of freshwater prairie cordgrass (*Spartina pectinata*). It is also home to several other locally rare species.

To protect the unique plants in and around Stumpy Basin, invasive species control plans have been targeting the removal of glossy buckthorn, garlic mustard (*Alliaria petiolata*), Japanese stiltgrass, and giant reed.

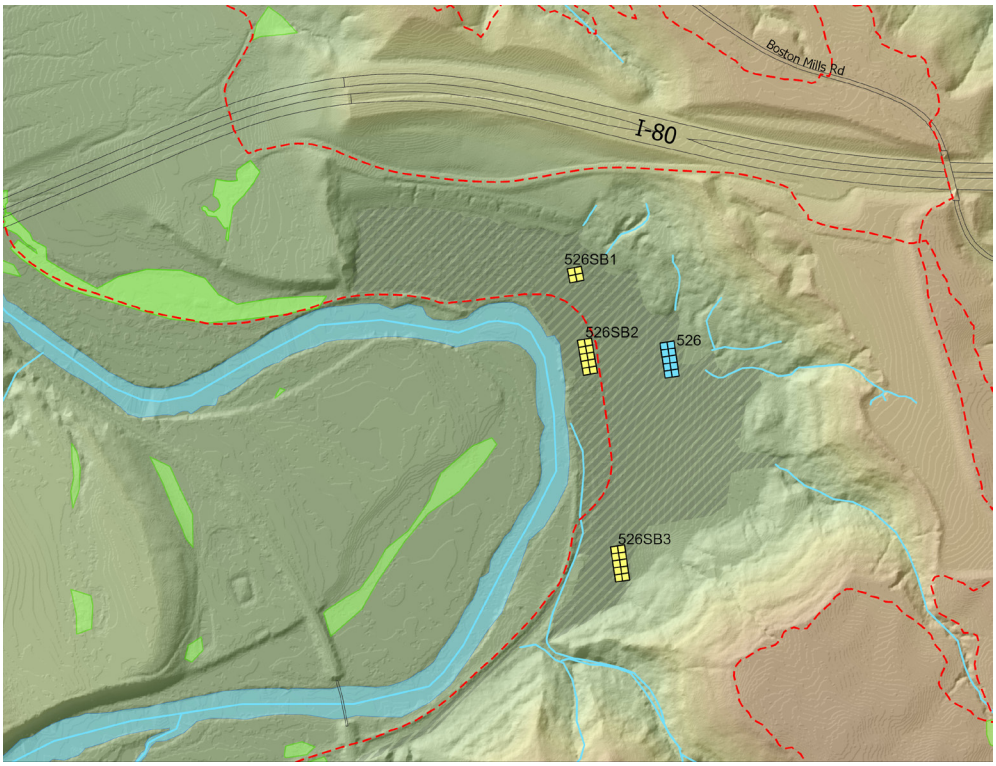


Figure 6. Stumpy Basin plot locations. Plots are color coded by Vegetation Index of Biotic Integrity (VIBI; dark blue = excellent, light blue = good, yellow = fair, white = poor). Highlighted wetlands are striped, and all others are light green. Parking lots are dark solid gray, trails are dashed red lines, and trailheads (if nearby) are labeled with a hiker icon and text. The Cuyahoga River and other tributaries are light blue. Scale = 1:5,000.

Virginia Kendall Lake

VIBI Score(s):

VK1 (North) = 26 (2009), 26 (2018)
VK2 (North) = 57 (2009), 64 (2018)
VK3 (South) = 84 (2009), 84 (2018)
VK4 (South) = 67 (2009), 74 (2018)

ORAM Score(s):

North = 58 (2008)
South = 70.5 (2011)

HGM/Vegetation Type: riverine mainstem, depressional, slope, impoundment/marsh, forest and shrub swamp

Size:

North = 8.4 acres
South = 5.7 acres

Virginia Kendall Lake is in the former Virginia Kendall State Park Historic District. This District was one of the first areas preserved in the vicinity of Cuyahoga Valley NP. However, much of the land was agricultural in the 1800s. It was grazed by sheep and cows and farmed for corn until Hayward Kendall purchased 430 acres of land and preserved it as a state park in perpetuity in honor of his mother, Virginia Kendall, in the early 1900s (Vasarhelyi 2021). The Akron Metropolitan District managed the land and utilized a Civilian Conservation Corps (CCC) Camp (Company 576) to convert the land into an active recreation area. They dammed Salt Run in 1937, created a loop trail around the lake and a sandy beach for fishing and swimming, and built a toboggan chute for sledding. The pine plantations (i.e. white pine [*Pinus strobus*] and scotch pine [*Pinus sylvestris*]) were also planted around this time. The district became a part of the park in 1974, and afterwards became more passively managed for its natural beauty. The dam was reconstructed and the lake was dredged and restocked with fish in 2010.

The Virginia Kendall (VK) Lake wetland system includes two wetlands that flank the two major tributaries of Virginia Kendall Lake (Figure 7) with the southern wetland in relatively better condition. The north wetland is identified as 242, while the south wetland is identified as 241. Wetland 241 (at plot VK3) was also selected as a reference wetland.

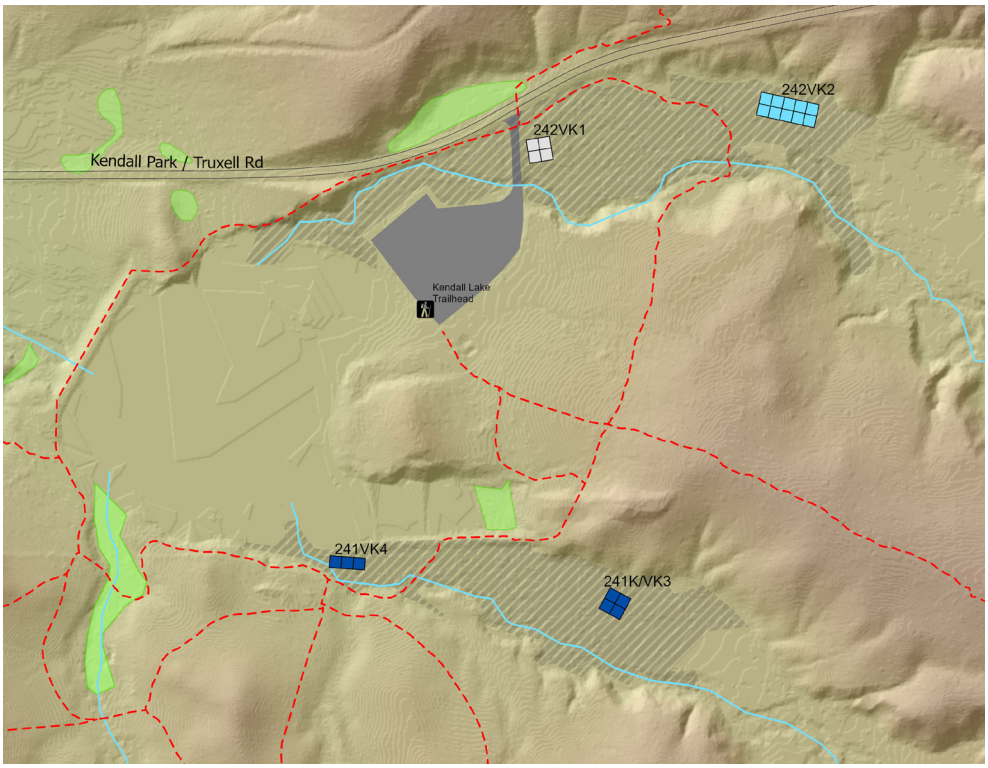


Figure 7. Virginia Kendall Lake plot locations. Plots are color coded by Vegetation Index of Biotic Integrity (VIBI; dark blue = excellent, light blue = good, yellow = fair, white = poor). Highlighted wetlands are striped, and all others are light green. Parking lots are dark solid gray, trails are dashed red lines, and trailheads (if nearby) are labeled with a hiker icon and text. The Cuyahoga River and other tributaries are light blue. Scale = 1:4,000.

The southern wetland is an approximately 8.4-acre marsh, fed by groundwater seeps, floodwaters from upper Salt Run, and fluctuations in lacustrine conditions created by beaver activity. The plots ranked within the *good* or *excellent* range in 2018, while the ORAM ranked as *excellent*. The VIBI scores at plot VK3, located higher in the watershed, were the same during 2009 and 2018. This plot consistently scored among the highest of all wetlands surveyed. This section of the wetland has a stable groundwater seep and water levels have been at or above the surface all year round since groundwater monitoring began here in 2009 (unpublished 2009–2021 data). The most common native plants were skunk cabbage, swamp goldenrod, brome-like sedge, groundnut (*Apios americana*), and marsh fern. Dominant shrubs include pussy willow (*Salix discolor*), silky willow (*Salix sericea*), and American black currant (*Ribes americanum*). The VIBI score at plot VK4 increased seven points from 2009 to 2018. The lake was dredged in 2010, which required a drawdown of lake water levels for several months. Beavers continually attempted to dam both major tributaries during that time. There was also evidence of active channel reconstruction (soil manipulation) and backwater pools in the wetland area around the VK4 plot. The natural stream channel flow was restored by the 2018 survey. Invasive shrubs, namely Morrow's honeysuckle (*Lonicera morrowii*), were also prevalent in 2009 surveys at plot VK4 but volunteers removed these large shrubs in 2017, which may have contributed to the improved condition.

The VIBI score for plot VK2 in the northern wetland fell within the *good* range, while plot VK1 was ranked as *poor*. The location higher up in the watershed likely explains the better condition of plot VK2. Also, plot VK1 is adjacent to the parking lot, trails, and the lake. In addition to groundwater, this wetland receives surface water runoff and alluvium from a small primary headwater stream. These sediments create changing conditions and likely bring in a steady flush of seed sources from upstream. Species richness (64.8, 68.3) was higher in both survey years

at plot VK2 than any other sentinel wetland. In 2018, the coverage of invasive species at plot VK2 increased substantially. A patch of reed canary grass nearly tripled in cover, and the more recently established invasive Japanese stiltgrass increased from 0% cover to between 75% and 90% cover in the plot over the nine years. Efforts began in 2015 to try to manage this invasive in the VK Lake watershed, but the feasibility of eradication seems very low. Despite the thick cover of Japanese stiltgrass at plot VK2, the plant community yielded high VIBI (57, 64) and FQAI (22.4, 24.7) scores. Other invasive species, mostly the hybrid cattail (*Typha* × *glauca*), are prevalent (>54.6%) at that plot and displace other high-quality wetland plants that would otherwise persist there (i.e, skunk cabbage, brome-like sedge, and sensitive fern [*Onoclea sensibilis*]). Woody plants appeared to be recovering in an old scrub-shrub community at VK1 between 2009 and 2018 with arrowwood viburnum (*Viburnum dentatum*), Missouri River willow (*Salix eriocephala*), and dogwoods increasing in abundance.

Restoration-Wetlands of Management Concern

Fawn Pond

VIBI Score(s):
FP1 = 69 (2018)
FP2 = 20 (2013), 29 (2018)
FP3 = 58 (2013), 64 (2018)
FP 4 = 54 (2013), 64 (2018)
FP 5 = 44 (2013), 60 (2018)
ORAM Score(s): 64 (2009)
HGM/Vegetation Type: riverine mainstem/marsh
Size: 136.2 acres

Fawn Pond has a long history of disturbance but is now a large wetland complex that supports many plant and animal species. The largest pond on the site, Fawn Pond, was a sand and gravel pit prior to being filled with water in 1963. Much of the land surrounding the pond was part of the Brecksville Wastewater Treatment Plant. The sewer system is now tied in with the Cleveland Interceptor, but gravel roads (Sanitation Road) that provide access to sewer access chambers still transect the wetland. In addition, much of the northwestern portion of Fawn Pond was once farmed, as evidenced by old fencing and a series of drainage ditches that drain water toward the Cuyahoga River. Despite the extensive disturbance history, the Fawn Pond wetland complex has shown remarkable recovery and is now the largest wetland complex at Cuyahoga Valley NP. Its size is the result of a complex hydrological regime. It is fed by two perennial streams on the west side of Riverview, groundwater from the southern slopes, and periodic flood waters from the Cuyahoga River. Most of Fawn Pond is saturated near the ground surface all year round. However, the forested land at the north end of the wetland is generally only submersed in the spring when the river exceeds flood stage. Beavers are active in the area, and they have maintained a large dam that has separated the Fawn Pond from an abandoned Oxbow for at least a couple decades (Wilder and McCombs 1999). Fawn Pond scored within the *excellent* range on the ORAM in 2009 because of its hydrological and habitat diversity.

Five VIBI plots represented the co-dominant swamp, marsh, and wet meadow communities. Four of the VIBI plots scored within the *good* range in 2018 (Figure 8). The score at plot FP2 was *poor*. This plot is located near a major tributary with heavy development in its watershed and associated with problematic stormwater issues. The tributary was channelized and dredged to reduce flooding in a nearby residential neighborhood. Scores improved at all Fawn Pond plots in 2018 compared to 2013 despite the increase in invasive graminoids in most locations. Reed canary grass, hybrid cattail, and giant reed cover extensive area across Fawn Pond. VIBI plots FP1 and FP5 ranked among the highest in species richness (56.3 and 41.3) of all sentinel wetlands. Common native species across the plots included crested sedge, Emory's sedge (*Carex emoryii*), fox sedge (*Carex vulpinoidea*), spotted touch-me-not, riverbank wildrye (*Elymus riparius*), rice cutgrass, swamp smartweed (*Persicaria hydropiperoides*), clearweed, blue skullcap (*Scutellaria lateriflo*ra), northern bugleweed (*Lycopus uniflorus*), and sensitive fern.

This wetland was evaluated by The Nature Conservancy (TNC) for a mitigation banking opportunity, but the plan was abandoned due to land use disagreements with nearby jurisdictions (Andrew Bishop, personal communication). The TNC report should be referred to when reviewing existing conditions and restoration concepts at Fawn Pond (TNC 2017). However, this plan did not emphasize hydrological restoration, which is likely the truest form of restoration at Fawn Pond because the past land-use practices involved ditching, diverting, and

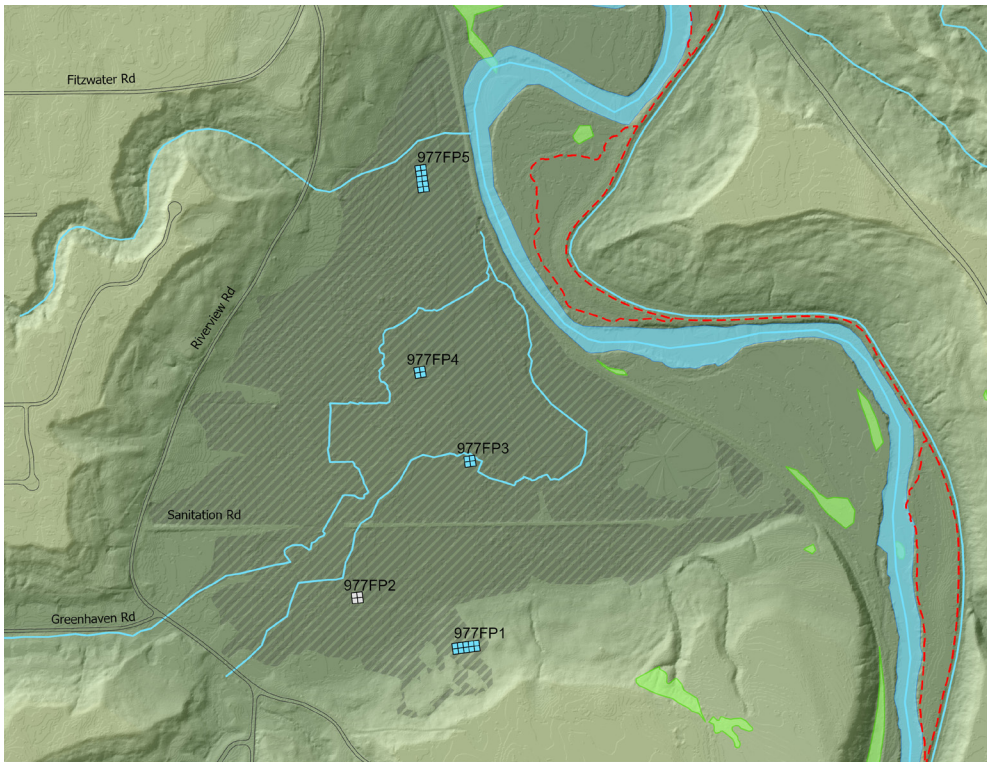


Figure 8. Fawn Pond plot locations. Plots are color coded by Vegetation Index of Biotic Integrity (VIBI; dark blue = excellent, light blue = good, yellow = fair, white = poor). Highlighted wetlands are striped, and all others are light green. Parking lots are dark solid gray, trails are dashed red lines, and trailheads (if nearby) are labeled with a hiker icon and text. The Cuyahoga River and other tributaries are light blue. Scale = 1:6,500.

culverting water throughout the site and the incoming streams lose their defined bed and bank in many areas. Stormwater issues will also continue to be problematic here.

Stanford Run

VIBI Score(s):
SF1 = 10 (2015), 7 (2018)
SF2 = 7 (2015), 19 (2018)
SF3 = 10 (2015), 10 (2018)
SF4 = 13 (2015), 10 (2018)
ORAM Score(s): 59.5 (2016)
HGM/Vegetation Type: riverine headwater, depressional/wet meadow, marsh, swamp forest
Size: 33.5 acres

The Stanford Run wetlands are comprised of mostly marsh and wet meadow communities. Water sources in the wetland include several small streams, groundwater, and in recent years, surface water from Stanford Run. This perennial water source created numerous stream channels and sediment deposits throughout the southern portion of the wetland. The natural hydrological conditions within the Stanford Run area were altered with the construction of the towpath trail in the early 1820s, as well as upstream developments and increased sediment loads within the Stanford Run watershed (Atkins 2011). Aerial photos from 1938 and 1959 indicate much of the existing wetland area was still agricultural. The eventual filling of the stream channel due to sedimentation/aggradation blocked the natural water flow, and the water was diverted across the adjacent old fields, resulting in the creation of the large wetland area monitored here. Stream channel restoration was proposed in 2011 to restore the stream's natural flow within a historical alignment (Atkins 2011). We established 4 VIBI plots in the vicinity of the project footprint to document the changes to the wetland hydrology and associated plant community health (Figure 9) before and after the restoration work was completed. The plots were surveyed in 2015 and again in 2018 just before stream restoration activities began in 2019.

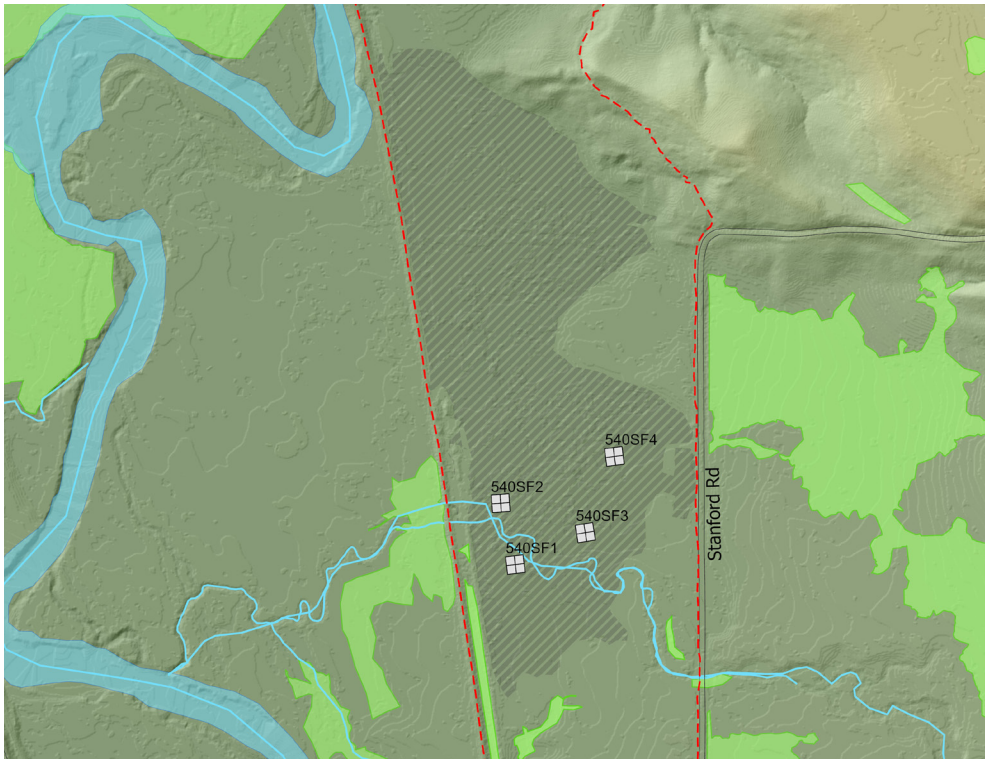


Figure 9. Stanford Run plot locations. Plots are color coded by Vegetation Index of Biotic Integrity (VIBI; dark blue = excellent, light blue = good, yellow = fair, white = poor). Highlighted wetlands are striped, and all others are light green. Parking lots are dark solid gray, trails are dashed red lines, and trailheads (if nearby) are labeled with a hiker icon and text. The Cuyahoga River and other tributaries are light blue. Scale = 1:4,000.

The VIBI scores for all plots were *poor* and lower than almost all other wetlands in the sentinel set. Invasive graminoids (66–100%) dominated all plots during both survey years, and the number of native plants diminished in 2018. Giant reed is dominant and inhibits understory growth. Species richness numbers ranged from 1.3 (plot SF3) to 12.8 (plot SF2) herbaceous species per plot in 2018. There is a gap in the coverage of the giant reed at plot SF2 because of the presence of American sycamore (*Platanus occidentalis*) and black willow (*Salix nigra*) trees.

Restoration work began in 2019 and was completed in 2020, reconnecting approximately 1,940 feet of perennial stream to the Cuyahoga River. The project required substantial channel excavation, but floodplain excavation was minimal, which resulted in a very confined channel with some small built-in floodplain benches. The work is expected to substantially change the hydrological conditions and associated vegetation communities within the wetland in the next decade. Annual water level data from well monitoring will be valuable to determine whether the wetland will be sustained by any groundwater inputs or gradually dry. The expectation is a gradual drying, as the new channel is substantially lower than the pre-restoration grade, and its steep banks will prevent regular flooding. The Cuyahoga Valley NP exotic plant management team is attempting giant reed control near the newly reconnected channel to help improve the chances for native species re-establishment. However, this invasive is prevalent throughout the extent of the wetland and persistent efforts will be critical for success. Future VIBI sampling will indicate how the plant community is responding to the changed hydrology and giant reed control. We originally expected plots SF1 and SF3 to be most affected by the restoration due to their proximity to the channel. However, plots SF3 and SF4 showed the most dramatic decreases in water levels in 2020 (unpublished data). Some native plants that persisted across this area during the 2018 surveys include spotted touch-me-not, fox sedge, enchanter's

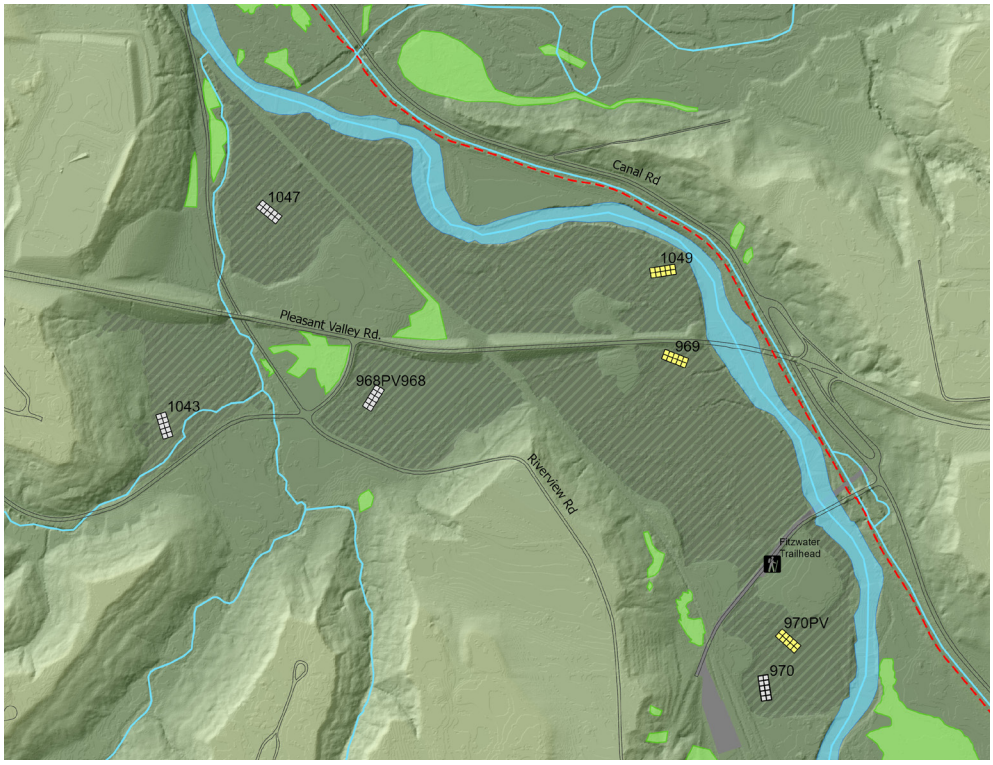


Figure 10. Pleasant Valley plot locations. Plots are color coded by Vegetation Index of Biotic Integrity (VIBI; dark blue = excellent, light blue = good, yellow = fair, white = poor). Highlighted wetlands are striped, and all others are light green. Parking lots are dark solid gray, trails are dashed red lines, and trailheads (if nearby) are labeled with a hiker icon and text. The Cuyahoga River and other tributaries are light blue. Scale = 1:7,000.

nightshade (*Circaea lutetiana)*, Virginia wildrye (*Elymus virginicus*), fowl manna grass (*Glyceria striata*), rice cutgrass, and woolgrass (*Scirpus cyperinus*).

Pleasant Valley

VIBI Score(s):

968 = 13 (2008), 7 (2018; see Brookside)
969 = 45 (2008), 43 (2018)
970PV = 33 (2008), 32 (2018)
1043 = 23 (2008), 25 (2018)
1047 = 13 (2008), 10 (2018)
1049 = 30 (2008), 47 (2018)

ORAM Score(s):

968 = 57.5 (2008)
969 = 48.5 (2008)
970 = 58 (2010)
1043 = 42.0 (2008)
1047 = 47.0 (2008)
1049 = 55.5 (2008)

HGM/Vegetation Type: riverine mainstem, depressional, slope/marsh, swamp, wet meadow

Size:

968 = 15.0 acres
969 = 34.2 acres
970 = 12.8 acres
1043 = 13.0 acres
1047 = 13.7 acres
1049 = 33.0 acres

The Pleasant Valley wetland complex is transected by four major transportation routes (i.e., Pleasant Valley Road, Brookside Road, CVSR Railroad, and Riverview Road), breaking up what may have once been a large contiguous system into nine distinct wetlands—six of them were studied here (968 [Brookside], 969, 970, 1043, 1047, and 1049; Figure 10). Brookside is also discussed independently (see below) due its history as a mitigation site. All Pleasant Valley wetlands have varying degrees of disturbance from historical land uses such as mining, dumping, ditching, grading, and farming. These highly manipulated areas have been the subject of restoration efforts for decades (DRG 2001; VHB and DRG 2011). They are disturbed but also functional

floodplain wetlands. In 2008, these wetlands were the first sentinel wetlands ever surveyed; they were resurveyed in 2018. A VIBI plot was placed in representative vegetation community type (wet meadow, marsh, swamp) for each wetland. The VIBI plot scores ranged within the *poor* to *fair* categories in 2018. Scores declined for half of the plots from 2008 to 2018.

Pleasant Valley marshes (968, 1047) ranked within the poor range. Brookside (968) had the lowest VIBI scores across the wetland complex in 2018. Both marshes have standing water much of the year and are dominated (>79.2%) by three species: narrowleaf cattail (*Typha angustifolia*), giant reed, and reed canary grass. Brookside is the oldest of four existing compensatory mitigation sites at Cuyahoga Valley NP, and it had the largest decrease in overall condition from 2008 to 2018. The percent cover of invasive graminoids increased from 66.3% to 97.7% and average species diversity per module declined from 24.8 to 6.5 during that time. The invasive graminoids have formed extensive monocultures and VIBI scores will likely continue to decline with the loss of diversity. Native plants are uncommon in both marshes and only included spotted touch-me-not, sandbar willow (*Salix interior*), black willow, smartweed (*Polygonum* spp.), and swamp milkweed in 2018. Even so, several rare marsh birds were documented here in 2012 and 2017 (Marcum and Bingham 2018) and a diverse array of anuran breeding populations are recorded here annually (unpublished Frogwatch data).

The Pleasant Valley wet meadow communities (969, 1043) scored as *fair* and *poor*, respectively. Reed canary grass was well established as dominant or co-dominant in 2018, corresponding with declines in species richness. Plot 1043 had greater coverage (85.7%) of this invasive than plot 969 (15.3%) in 2018 and a correspondingly lower VIBI score (25) and species richness (12.3) than plot 969 (43 and 26). Some native plants that persist include common horsetail, spotted touch-me-not, crested sedge, fox sedge, and hemp dogbane. However, these species are likely to diminish in the next several years as invasive plants continue to spread.

The swamp forests at plots 970 and 1049 scored in the *fair* range during both survey years. Wetland plot 1049 had higher species richness (33.3) than plot 970 (15). The plot was dominated by box elder and cottonwood and had a few species of note in the understory, including a population of ostrich fern (*Matteuccia strathiopteris*) and green dragon (*Arisaema draconitum*) that persisted across both surveys. In contrast to the invasive graminoids typically found in the understory, these plants are some of the more sensitive native herbs in the floodplain of the Cuyahoga River. Wetland plot 970 was dominated by silver maple and cottonwood with more common understory species such as false nettle (*Boehmeria cylindrica*), white grass (*Leersia virginica*), jumpseed, wild ryes, and poison ivy. Both plots have established populations of reed canary grass (<16%), and garlic mustard is also a concern at plot 1049.

Conceptual restoration plans were completed for Pleasant Valley in 2011. However, a great deal of earthwork, soil remediation, and invasive plant removal may be required for successful restoration (VHB and DRG 2011). For this reason, the Pleasant Valley wetlands are still overlooked when restoration opportunities are considered. However, the park hopes to secure funding to make these restoration concepts reality and improve the interconnectivity and integrity of this wetland complex.

Mitigation-Wetlands of Management Concern

Krejci

VIBI Score(s):
KR1 = 46 (2014), 49 (2018)
KR2 = 29 (2014), 51 (2018)
ORAM Score(s):
1622 (marsh) = 44 (2016)
1627 (wet meadow) = 42 (2016)
HGM/Vegetation Type: depressional, slope/marsh, wet meadow
Size:
1622 = 1.1 acres
1627= 0.9 acres

The Krejci mitigation wetlands were constructed in 2012 as mitigation for impacts associated with the Krejci Dump and associated remediation actions. The Krejci dump was an industrial waste salvage yard from 1948–1980 before being acquired by the NPS in 1985 (DRG 2017). General cleanup began in 1987 and remedial actions were completed by 2011. The Krejci wetlands were designed to be a mosaic of seven marsh and wet meadow wetlands interspersed

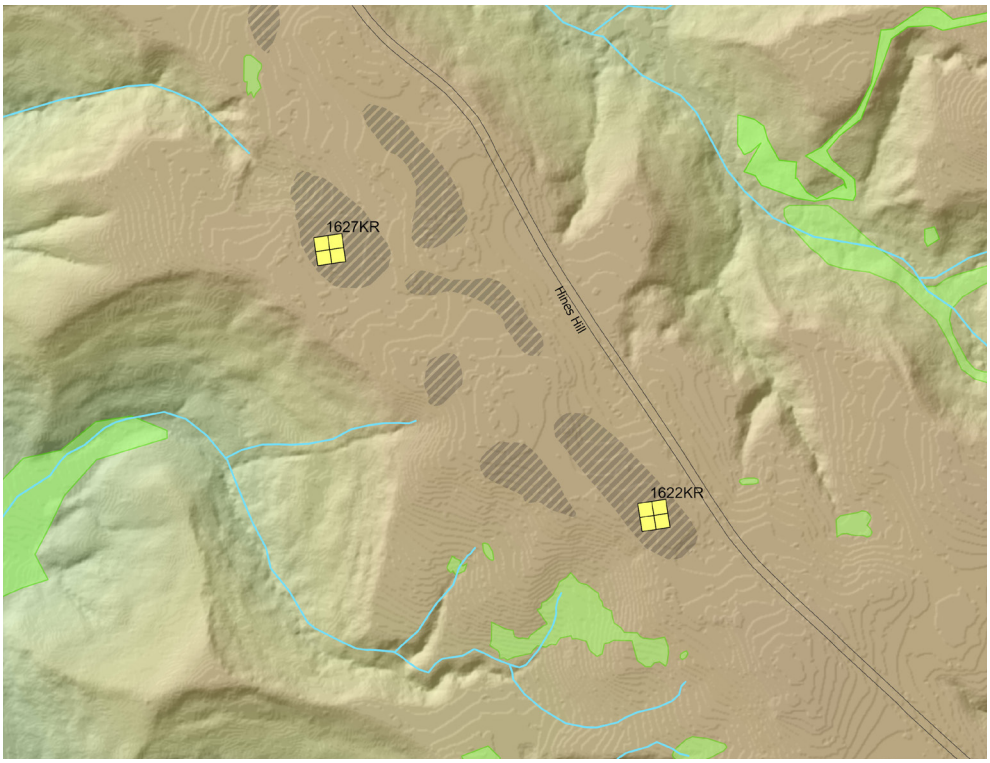


Figure 11. Krejci plot locations. Plots are color coded by Vegetation Index of Biotic Integrity (VIBI; dark blue = excellent, light blue = good, yellow = fair, white = poor). Highlighted wetlands are striped, and all others are light green. Parking lots are dark solid gray, trails are dashed red lines, and trailheads (if nearby) are labeled with a hiker icon and text. The Cuyahoga River and other tributaries are light blue. Scale = 1:2,500.

with upland prairie habitat (Figure 11). The deeper marshes were designed to collect surface water runoff higher up in the watershed. The water then cascades toward the shallower wet meadows before draining west into three primary headwater streams that drain into Stanford Run. In 2017, after 5 years of site maintenance and monitoring, Davey Resource Group (DRG) documented successful creation of 6.9 acres of wetlands with a VIBI score in the *excellent* range (84). The VIBI score was based on one representative, subjectively located plot. Mitigation requirements specified 3 acres of Category 2 (VIBI score >57) wetlands, >75% cover of native hydrophytes, <10% unvegetated open water, and <5% invasive species cover. These conditions were met in 2017 (DRG 2017) and the contractor was released from further maintenance and monitoring.

NPS staff established two separate VIBI plots at the site to monitor long-term trends (Figure 11). To cover each of the distinct vegetation types, plot KR1 was placed to capture marsh at 1622 and plot KR2 was placed to capture wet meadow at 1627. Both plots were randomly located within the selected wetlands and surveyed in 2014 and 2018. The VIBI scores increased at both plot locations between survey years and fell within the *fair* range in 2018. Scores increased only slightly at plot KR1 (46 to 49), but there was a large increase at plot KR2 (29 to 51). The overall plant community and habitat development were good and should continue to improve over



Krejci Dump in 1981. NPS

time if invasive species are controlled. At the time of the 2018 survey, individuals of Giant reed and cattails were present, but in very low abundance (<1%). The most common native plants in the marsh plot included blunt spikerush (*Eleocharis obtusa*), pickerelweed (*Pontederia cordata*), longleaf pondweed (*Potamogeton nodosus*), softstem bulrush (*Schoenoplectus tabernaemontani*), and water purslane. Common native plants in the wet meadow plot include longhair sedge (*Carex comosa*), bluejoint (*Calamagrostis canadensis*), common spikerush (*Eleocharis palustris*), rice cutgrass, green bulrush (*Scirpus atrovirens*), and prairie cordgrass. The unique position of this perched wetland habitat at the top of the valley has led to abundant amphibian usage, including *Ambystoma* spp. (unpublished data).

Rockside

VIBI Score(s): RS1= 12 (2015), 13 (2019)
ORAM Score(s): 50.5 (2012/2013)
HGM/Vegetation Type: depressional (impoundment), slope//marsh
Size: 6.4 acres

The Rockside marsh was constructed in 2007 as a mitigation site for impacts associated with the Ohio Department of Transportation I-271 bridge replacement (Figure 12). It is located at the northern-most terminus of the park boundary and is surrounded by commercial and residential land uses. The wetland collects surface runoff from slopes and primary headwater streams to the west and south, as well as some groundwater and discharges to a stream located to the north of the site. Water levels are controlled by a weir. Minimum mitigation requirements included creation of 1.28 acres of wetlands; <10% unvegetated open water; >80% coverage of native hydrophytes; <15% cover of invasive marsh species, including narrowleaf cattail, hybrid cattail, purple loosestrife (*Lythrum salicaria*), reed canary grass, giant reed, and buckthorns (*Rhamnus* spp.); and VIBI scores within the Category 2 (*good*) range. The wetland was approximately 4.1 acres with a VIBI score of 46 in 2012, and all mitigation requirements were met (ODOT 2012). Active maintenance and monitoring ceased at that time—although the park's exotic plant management



Figure12. Rockside plot locations. Plots are color coded by Vegetation Index of Biotic Integrity (VIBI; dark blue = excellent, light blue = good, yellow = fair, white = poor). Highlighted wetlands are striped, and all others are light green. Parking lots are dark solid gray, trails are dashed red lines, and trailheads (if nearby) are labeled with a hiker icon and text. The Cuyahoga River and other tributaries are light blue. Scale = 1:2,500.

team used some invasive plant treatments to control common reed through 2015 after the mitigation contract ended.

The vegetative quality of the Rockside wetland started to deteriorate rapidly following mitigation. The VIBI score at the Rockside plot was within the *poor* range in 2015 and 2019. The percent cover of the listed invasive graminoids increased substantially over that time (20.7% to 51.6%) at the plot location. The largest increase was the coverage of giant reed and cattails. Native species common in the VIBI plot included crested sedge, soft rush (*Juncus effusus*), broadleaf arrowhead (*Sagittaria latifolia*), softstem bulrush, and broadfruit bur-reed. Giant reed is widespread in the area surrounding the marsh and will be very difficult to keep under established thresholds without persistent maintenance. Despite the *poor* condition documented in the VIBI plot, this wetland is one of the few large marshes in the park, frequently visited by several rare marsh birds, and notable as a local breeding pond for amphibians (Marcum and Bingham 2018).

Brookside

VIBI Score(s): 968 = 13 (2008), 7 (2018)
ORAM Score(s): 57.5 (2008)
HGM/Vegetation Type: depressional (impoundment)/ marsh
Size: 15.0 acres

The Brookside marsh is part of the Pleasant Valley wetland complex but is reported separately since the wetland was restored to meet mitigation requirements (Figure 10). It is the oldest of four compensatory wetland mitigation sites at Cuyahoga Valley NP—constructed in November 1999 to mitigate impacts associated with the Ohio Turnpike I-80 bridge replacement. It is bound on all sides by three roads and the Cuyahoga Valley Scenic Railroad and receives surface water runoff from a small watershed and several small hillside seeps nearby. Mitigation requirements were less specific at that time, only requiring 3.586 acres of wetland restoration with mixed marsh and wet meadow habitats within the Category 2 (*good*) range, which was 17–30 at that time (ORAM v 4.0, DRG 2004).

The contractor was released from their mitigation obligations in 2004 after five years of monitoring that documented approximately 3.8 acres of marsh with an ORAM (v 4.0) score of 28 and 96 plant species within the wetland. Control of giant reed ceased at Brookside after the mitigation contract ended.

Brookside has one VIBI plot that scored as *poor* during both surveys; the score decreased over that time. Species richness also declined substantially from 24.8 to 6.5 across survey years. Three invasive graminoids dominate the area: narrowleaf cattail, giant reed, and reed canary grass. The percent cover of these species increased in the plot from 66.3% to 97.7% between 2008 and 2018. Although uncommon, a few native plants such as spotted touch-me-not, sandbar willow, black willow, smartweed, and swamp milkweed were documented in 2018. Several rare marsh birds and a diverse array of anuran breeding populations continue to occupy the wetland (Marcum and Bingham 2018; unpublished Frogwatch data).



Common reed (*Phragmites australis)* in Brookside marsh, Cuyahoga Valley NP, Ohio. NPS/SONIA BINGHAM

Discussion

VIBI Scores Across Large Wetland Complexes

The multiple VIBI plots dispersed throughout larger wetlands in Cuyahoga Valley NP help detect and illuminate the spatial patterns in condition. Localized disturbances, past modifications, and management actions appear to be evident with the VIBI since many individual wetlands have a wide range of plot scores within their boundaries. These plots often detect localized problems that may become larger in time without interventions. From a regulatory perspective, the highest scoring VIBI plot within a wetland is used for assigning the final anti-degradation category (Mack and Gara 2015) and those are listed for each wetland (Appendix A) based on 2018 scores. For example, Beaver Marsh categories ranged from *fair* in disturbed areas to *excellent* in the most protected areas. Since the highest scoring plot is used for final categorization of the wetland complex, Beaver Marsh would be considered in *excellent* wetland condition overall (Category 3).

ORAM and VIBI Discrepancies

Anti-degradation categories based on the ORAM aligned with the 2018 VIBI categories in 40% of the wetland plots. In 60% of the cases, the ORAM rated wetlands with a higher category. These indices were highly correlated in previous studies (Mack and Gara 2015) despite the discrepancies that we observed. In most cases, the VIBI guidance recommends that a single VIBI plot location is placed strategically in a representative location within the wetland (Mack and Gara 2015), whereas multiple plots were used in this case, and they were randomly placed to minimize bias (Bingham et al 2016). Furthermore, the ORAM and VIBI surveys were conducted as much as 10 years apart so the ORAM would not have captured recent changes in the wetland environment. Finally, wetlands of management concern are large and complex with multiple community types, hydrogeomorphic (HGM) classes, and water sources, and all these factors contribute to higher scores on the ORAM. As a qualitative index, the ORAM metrics are generally coarse by design and would not be expected to detect subtle disturbances and impairments that are possible with the VIBI. A new ORAM survey will be completed when the sentinel wetlands are revisited for VIBI surveys in 2023.

Vernal Pools

The two depressional reference wetlands are high quality vernal pools based on amphibian metrics. However, they do not compare well to each other based on VIBI scores. The Langes pool has limited options for vegetation development based on its topographic relief and scores very low even though it has a buttonbush community and a unique floating mat. The Boston Mills pool is nearly four times larger with gradual changes in topography and offers a mixed vegetation community that ranges from swamp forest to emergent marsh. Deeper vernal pools are best evaluated using the Amphibian Index of Biotic Integrity (AmphIBI; Micacchion 2004).

How Do Cuyahoga Valley NP Reference Wetlands Score in Comparison to Established Ranges?

Evaluation of the reference wetlands indicated that our initial selection of high-quality wetlands was accurate for the depressional Boston Mills wetland, slope wetlands at VK Lake and Columbia Run, and the riverine headwater wetland at Stumpy Basin. These sites met pre-established reference-quality ranges (ORAM scores >60, VIBI scores >74, FQAI scores >20) and they allow us to monitor changes in the highest quality wetlands in Cuyahoga Valley NP. However, they are still subject to degradation from hydrological alteration or non-native plant invasion. Snowville, Langes, Fitzwater, and Bath fell within the *fair* and *poor* ranges and may not be ideal representations of best attainable condition at the park. However, high quality wetland habitats within the riverine mainstem and depressional HGM classes seem to be relatively uncommon at the park based on a random sample of 60 wetlands (Bingham, unpublished). Pre-established ranges may be difficult to attain at riverine mainstem and depressional wetlands, which have consistently lower scores on these indices across the board.

We suggest that reference wetlands serve as important demonstration sites where park managers should consider maintaining exemplary conditions through active management. Through this work, park



Plot setup at Krejci mitigation wetlands in 2015, Cuyahoga Valley National Park, Ohio. NPS/SONIA BINGHAM

managers can evaluate the feasibility, effectiveness, and scalability of management practices required to maintain wetland condition. We will evaluate the option to replace the lower scoring reference wetlands with known high-quality wetlands in the same HGM classes.

How are Cuyahoga Valley NP Mitigation Wetlands Faring Over Time?

Metric scores across the mitigation wetlands of management concern plots were low. Two of the three mitigation wetlands are not meeting the benchmarks originally established by the United States Army Corps of Engineers and Ohio Environmental Protection Agency. Contractor reports state that the wetlands met the criteria within the first five years of establishment. However, upon release from monitoring and maintenance, invasive species gradually re-established, which has led to deterioration over time. Brookside had the highest increase in percent invasive graminoids among all sentinel wetlands and Rockside was a close second. These wetlands would require a substantial new investment in time (and pesticide use) to meet the original restoration goals of *good* wetland condition (Category 2). However, volunteers have continued to document important breeding birds and amphibians using these wetlands (Breeding Bird Census and Frogwatch), so the efforts may be fruitful. The wetland communities at Krejci continued to mature between survey years and plot scores increased. We would expect this trend to continue at Krejci if the encroachment of invasive species is controlled. Giant reed and cattails should be targeted each year.

Status of Park-selected Restoration Wetlands

The restoration wetlands were selected around 2005. Since then, progress has varied: (1) a Conceptual Restoration Plan was completed at Pleasant Valley by Vanasse Hangen Brustlin, Inc. and Davey Resource Group (VHB and DRG 2011), (2) a Draft Restoration Concept Plan was completed for Fawn Pond (TNC 2017), and (3) stream restoration was completed at Stanford Run (based on Atkins 2011), and substantial water level declines are expected throughout the wetland in response.

The minimum goal for most wetland restoration projects is a VIBI score within the *good* range over time (VIBI > 60). Pleasant Valley and Stanford are

in *poor* ecological condition and have the lowest scoring VIBI plots within the entire sentinel wetland set. These wetlands have excellent restoration potential, but will also require more work, higher costs, and a longer-term commitment for success. Pleasant Valley was highly manipulated in the past and a great deal of earthwork, soil remediation, and invasive plant removal may be required for successful restoration (VHB and DRG 2011). For this reason, the Pleasant Valley wetlands are still overlooked when restoration opportunities are considered. The stream restoration work and the reed canary grass and cattail treatments implemented at Stanford Run since 2019 are expected to change the index scores in future monitoring. The post-restoration survey is scheduled for 2023.

Fawn Pond was also highly manipulated in the past but has shown a great deal of natural recovery in vegetation condition and maintains mostly *good* VIBI scores. Fawn Pond is the only restoration wetland of management concern with plot scores above 60 and is likely the best restoration candidate of these three sites based on the likelihood for long-term success. The channelized section near the southwest tributary is the lowest scoring area, where invasive species cover is very high. The Nature Conservancy's Draft Concept Plan (TNC 2017) for restoration at Fawn Pond provides some excellent baseline information as a starting point. Restoration goals should be based on Cuyahoga Valley NP's desired future conditions, and mitigation goals of outside partners may not always be in line with those. Land use disagreements and stormwater issues may also continue to be problematic here.

These restoration sites should be re-evaluated for their feasibility and potential success and given an order of prioritization relative to the newer list of restoration sites. Cuyahoga Valley NP has added many new areas to their list of potential wetland restoration sites after these areas were selected, and there may be better opportunities available based on restoration objectives.

What Are We Seeing With Invasive Species in Sentinel Wetlands? Should We Control Them?

Large fluctuations in condition across a single wetland complex appeared to be linked to local invasive plant infestations, and these infestations appear to be the most obvious and widespread threat to wetland ecosystems in Cuyahoga Valley NP, but also the most controllable threat. Fortunately, some sensitive species are still present in some of the lowest scoring plots, which indicates that invasive species control efforts may pay off immediately with a resurgence of native communities. The Heartland Network Invasive Plant Management Team (IPMT) has targeted reed canary grass control within rare plant communities at Stumpy Basin, and Cuyahoga Valley NP IPMT staff and volunteers have targeted reed canary grass control at scenic sections of the Beaver Marsh and at Stanford Run. Documenting changes in vegetation metric scores within those plots may help illustrate the value of invasive species control in wetlands of management concern as well as effectiveness and sustainability.

Water quality problems may be an underlying cause of invasive species spread and are known to limit diversity by eliminating plant species with more specific environmental requirements and favoring more tolerant, fast-growing, high biomass species. There are known or suspected water quality or sedimentation concerns at portions of Pleasant Valley, Fawn Pond, Beaver Marsh, Virginia Kendall Lake, Stanford Run, and Stumpy Basin. All these wetland systems have connections to streams or rivers that transport stormwater runoff from more developed areas outside of the park. Through partnerships with The Nature Conservancy and the Northeast Ohio Regional Sewer District, problematic stormwater areas can be targeted for possible long-term solutions within the watershed.

While restoration opportunities are more abundant over the last decade, it is important to consider whether restoration, especially mitigation projects, are sustainable over the long term since continued park-supported invasive species control efforts will be crucial for long-term success. A focus on invasive plant removal at reference wetlands and rare habitat sites would have large payoffs over time by protecting some of our most unique wetlands. In certain areas, the use of prescribed fire could greatly enhance the opportunity to achieve more extensive control in much less time and with a tremendous reduction in pesticide use.

Literature Cited

Andreas, B. K., J. J. Mack, and J. S. McCormac. 2004. Floristic quality assessment index for vascular plants and mosses for the State of Ohio. Wetland Ecology Group, Division of Surface Water, Ohio Environmental Protection Agency, Columbus, Ohio.

Atkins. 2011. Cuyahoga Valley National Park Stanford Run restoration project preliminary conditions report. Cuyahoga Valley National Park, Brecksville, Ohio.

Bingham, S. N., and C. C. Young. 2023. Sentinel wetlands in Cuyahoga Valley National Park: II. Condition and trends related to wetlands of management concern types, 2008–2018. National Park Service, Heartland Inventory and Monitoring Network, Brecksville, Ohio. (Draft manuscript).

Bingham, S. N., C. C. Young, J. L. Haack-Gaynor , L. W. Morrison, and G. A. Rowell. 2016. Wetland monitoring protocol for Cuyahoga Valley National Park: Narrative. Natural Resource Report NPS/HTLN/NRR—2016/1336. National Park Service, Fort Collins, Colorado.

Bishop, R. P., and J. K. Bishop. 1945. Old Stumpy Basin. Brecksville News. Brecksville, Ohio.

Davey Resource Group (DRG). 2001. GIS wetlands inventory and restoration assessment, Cuyahoga Valley National Park, Cuyahoga and Summit Counties, Ohio. Report prepared for HNTB Ohio, Inc., Cleveland, Ohio.

Davey Resource Group (DRG). 2004. Year Five Monitoring and Management Report, Riverview Road Wetlands Mitigation Project, Independence, Ohio. Report prepared for HNTB Ohio, Inc., Cleveland, Ohio.

Davey Resource Group (DRG). 2017. Year Five Monitoring and Management Report, Krejci Site Wetland Mitigation Project, Boston Township, Summit County, Ohio. Report prepared for U.S. Ecology, Livonia, Michigan.

Hop, K., J. Drake, A. Strassman, E. Hoy, J. Jakusz, S. Menard, and J. Dieck. 2013. National Park Service vegetation inventory program: Cuyahoga Valley National Park, Ohio. Natural Resource Technical Report NPS/HTLN/NRTR—2013/792. National Park Service, Fort Collins, Colorado.

Mack, J. J. 2001. Ohio rapid assessment method for wetlands, manual for using version 5.0. Ohio EPA Technical Bulletin Wetland/2001-1-1. Ohio Environmental Protection Agency, Division of Surface Water, 401 Wetland Ecology Unit, Columbus, Ohio.

Mack, J. J., and B. D. Gara. 2015. Integrated wetland assessment program. Part 9: field manual for the vegetation index of biotic integrity for wetlands v. 1.5. Ohio EPA Technical Report WET/2015-2. Ohio Environmental Protection Agency, Wetland Ecology Group, Division of Surface Water, Columbus, Ohio. Available at http://epa.ohio.gov/portals/35/wetlands/Part9_field_manual_v1_5rev15aug15.pdf (accessed 26 September 2016).

Marcum, D. J., and S. N. Bingham. 2018. Wetland breeding bird survey: Cuyahoga Valley National Park, 2012. Natural Resource Report NPS/HTLN/NRR—2018/1632. National Park Service, Fort Collins, Colorado.

Micacchion, Mick. 2004. Integrated wetland assessment program. Part 7: amphibian index of biotic integrity (AmphIBI) for Ohio wetlands. Ohio EPA Technical Report WET/2004-7. Ohio Environmental Protection Agency, Wetland Ecology Group, Division of Surface Water, Columbus, Ohio.

Ohio Department of Transportation (ODOT). 2012. 2012 permit compliance report for the SUM-271-8.02 (PID 21450) Project. United States Army Corps of Engineers (USACE) Public Notice No. 2004-00272(1), Ohio EPA # 042046.

Stoddard, J. L., D. P. Larsen., C. P. Hawkins, R. K. Johnson, and R. H. Norris. 2006. Setting expectations for the ecological condition of streams: the concept of reference condition. Ecological Applications 16: 1267–1276.

Swink, F., and G. Wilhelm. 1994. Plants of the Chicago region. 4th edition. Indiana Academy of Sciences, Indianapolis, Indiana.

The Nature Conservancy (TNC). 2017. Fawn Pond in-lieu fee draft concept plan: in partnership with Cuyahoga Valley National Park and Cleveland Metroparks Cuyahoga Watershed (HUC 04110002) Cuyahoga County, Ohio.

Vanasse Hangen Brustlin, Inc. and Davey Resource Group (VHB and DRG). 2011. Conceptual restoration plan, Cuyahoga Valley Wetlands Restoration Project, Cuyahoga County, Ohio.

Vasarhelyi, J. 2021. Kendall Lake through the years. National Park Service, Cuyahoga Valley National Park. Available at https://www.nps.gov/articles/000/kendall-lake-through-the-years.htm (last updated 2021; accessed 03 March 2022).

Wilder, G. J., and M. R. McCombs. 1999. A floristic study of Fawn Pond and surrounding territory (Cuyahoga Va lley National Recreation Area and Brecksville, Ohio). Castanea 64(1): 50–63.

Appendix A. Evaluation Metric Summary

Tables A1 and A2 contain the metric scores for all sentinel wetlands.

Table A1. Ohio Rapid Assessment Method (ORAM) scores and antidegradation categories at all sentinel wetlands. The highest scoring wetlands are Category 3 (excellent condition). The Final Category 2018 was determined based on the Vegetation Index of Biotic Integrity (VIBI) score, which supersedes the ORAM score. These are known to be positively correlated in previous studies. WOMC = wetland of management concern; Mod = Modified Category 2.

WetIndID	Name	Site Type	Size (ac.)	ORAM Date	ORAM Score	ORAM Antidegradation Category	Final Category 2018
124	Langes	reference	0.3	2010	64.0	2 or 3	1
683	Boston Mills	reference	1.6	2010	83.0	3	3
241	VK Lake South	reference / restoration	5.7	2011	70.5	3	3
554	Columbia	reference	2.1	2010	61.0	2 or 3	3
526	Stumpy Basin	reference / rare habitat	30.7	2008	73.5	3	2
398	Snowville	reference	10.7	2010	61.5	2 or 3	Mod 2
1427	Bath	reference	35.0	2010	67.0	3	Mod 2
970	Fitzwater	reference / restoration	12.8	2010	58.0	2	Mod 2
365	Beaver Marsh	rare habitat WOMC	67.9	2008	88.0	3	3
242	VK Lake North	rare habitat WOMC	8.4	2008	58.0	2	2
1622	Krejci	mitigation WOMC	1.1	2016	44.0	Mod 2	Mod 2
1627	Krejci	mitigation WOMC	0.9	2016	42.0	Mod 2	Mod 2
1079	Rockside	mitigation WOMC	6.4	2012/2013	50.5	2	1
968	Brookside	mitigation WOMC	15.0	2008	57.5	2	1
977	Fawn Pond	restoration WOMC	136.2	2009	64.0	2 or 3	2
969	Pleasant Valley	restoration WOMC	34.2	2008	48.5	2	Mod 2
1043	Pleasant Valley	restoration WOMC	13.0	2008	42.0	Mod 2	1
1047	Pleasant Valley	restoration WOMC	13.7	2008	47.0	2	1
1049	Pleasant Valley	restoration WOMC	33.0	2008	55.5	2	Mod 2
540	Stanford	restoration WOMC	33.5	2016	59.5	2	1

Table A2. Metric scores at sentinel wetlands for the baseline surveys between 2008 and 2015 and the follow up survey in 2018. PlotID = wetlandID and plot number. HGM = hydrogeomorphic class; classes are DP (Depressional), SP (Slope), RD (Riverine Headwater), RM (Riverine Mainstem). WOMC = wetland of management concern. FQAI = Floristic Quality Assessment Index score. VIBI = Vegetation Index of Biotic Integrity. %invasive = % cover of reed canary grass, cattails (*Typha angustifolia*, *T. latifolia*, *T. x glauca*), and giant reed. Species richness = average number of species in each 10-m × 10-m module.

Wetland Type	PlotID	Wetland Name	HGM	Survey Date	Modules	FQAI	% Sensitive	% invasive	VIBI State	VIBI Category	Species Richness
Reference Wetlands	124	Langes	DP	9/8/2014	4	9.8	0.0	0.0	23	1	11.0
	124	Langes	DP	8/30/2018	4	12.4	0.0	0.0	25	1	13.0
	683	BostonMills	DP	8/8/2014	10	19.1	58.6	0.0	84	3	21.0
	683	BostonMills	DP	7/17/2018	10	22.8	49.6	0.0	81	3	27.3
	241K (VK3)	Virginia Kendall	SP	8/12/2009	4	20.0	28.1	3.4	84	3	38.3
	241K (VK3)	Virginia Kendall	SP	8/20/2018	4	22.1	19.3	3.4	84	3	36.3
Reference Wetlands (continued)	554	Columbia	SP	9/10/2014	4	29.7	21.8	0.0	87	3	53.8
	554	Columbia	SP	7/18/2018	4	33.4	27.2	0.0	91	3	58.8
	526	Stumpy	RH	8/31/2011	10	27.2	40.4	0.0	90	3	36.8
	526	Stumpy	RH	7/12/2018	10	21.1	28.2	0.4	64	2	34.0
	398	Snowville	RH	9/15/2014	4	15.5	1.7	0.7	58	Mod 2	23.3
	398	Snowville	RH	8/31/2018	4	18.2	2.1	6.4	54	Mod 2	29.3
	1427	Bath	RM	8/14/2014	10	12.3	0.2	0.0	36	Mod 2	18.8
	1427	Bath	RM	8/30/2018	10	16.6	0.5	0.0	40	Mod 2	26.3
	970	Fitzwater	RM	8/21/2014	10	15.0	0.0	8.8	23	1	27.8
	970	Fitzwater	RM	7/5/2018	10	17.8	1.1	9.8	29	1	31.0
Rare Habitat Wetlands of Management Concern	365BM2	Beaver Marsh	RM	7/11/2011	4	17.8	8.3	5.9	71	2	39.5
	365BM2	Beaver Marsh	RM	8/22/2018	4	22.0	10.1	3.2	71	2	42.8
	365BM3	Beaver Marsh	RM	8/8/2011	4	22.4	17.1	6.4	81	3	44.5
	365BM3	Beaver Marsh	RM	8/27/2018	4	23.4	15.2	12.1	77	3	49.5
	365BM4	Beaver Marsh	RM	8/2/2011	10	16.6	2.6	44.0	33	Mod 2	26.8
	365BM4	Beaver Marsh	RM	8/28/2018	10	15.9	15.0	34.0	43	Mod 2	29.3
	365BM5	Beaver Marsh	RM	7/18/2011	4	15.4	18.1	3.1	71	2	31.0
	365BM5	Beaver Marsh	RM	8/28/2018	4	21.8	7.9	17.0	56	Mod 2	40.3
	365BM6	Beaver Marsh	RM	8/9/2011	8	15.6	4.5	6.7	57	2	38.8
	365BM6	Beaver Marsh	RM	8/23/2018	8	23.1	11.5	0.9	74	3	46.0
	526SB1	Stumpy Basin	SP	9/26/2011	4	17.1	1.2	37.9	46	Mod 2	29.3
	526SB1	Stumpy Basin	SP	7/16/2018	4	15.8	9.6	50.1	47	Mod 2	23.0
	526SB2	Stumpy Basin	RM	9/19/2011	10	16.1	1.3	3.9	40	Mod 2	36.3
	526SB2	Stumpy Basin	RM	7/4/2018	10	22.1	2.4	3.3	54	Mod 2	41.0
	526SB3	Stumpy Basin	SP	8/24/2011	10	20.0	2.4	0.0	51	Mod 2	30.8
	526SB3	Stumpy Basin	SP	7/11/2018	10	19.3	3.6	0.3	50	Mod 2	32.5
	242VK1	Virginia Kendall	SP	8/4/2009	4	9.8	1.7	81.8	26	1	21.5
	242VK1	Virginia Kendall	SP	8/16/2018	4	11.3	4.3	54.7	26	1	18.3
	242VK2	Virginia Kendall	RH	7/21/2009	10	22.4	6.6	0.6	57	2	64.8
	242VK2	Virginia Kendall	RH	8/14/2018	10	24.7	14.5	3.8	64	2	68.3
	241VK4	Virginia Kendall	RH	8/5/2009	3	20.5	1.9	2.4	67	2	51.3
	241VK4	Virginia Kendall	RH	8/16/2018	3	20.4	17.3	0.5	74	3	39.3

Table A2 (continued). Metric scores at sentinel wetlands for the baseline surveys between 2008 and 2015 and the follow up survey in 2018. PlotID = wetlandID and plot number. HGM = hydrogeomorphic class; classes are DP (Depressional), SP (Slope), RD (Riverine Headwater), RM (Riverine Mainstem). WOMC = wetland of management concern. FQAI = Floristic Quality Assessment Index score. VIBI = Vegetation Index of Biotic Integrity. %invasive = % cover of reed canary grass, cattails (*Typha angustifolia*, *T. latifolia*, *T. x glauca*), and giant reed. Species richness = average number of species in each 10-m × 10-m module.

Wetland Type	PlotID	Wetland Name	HGM	Survey Date	Modules	FQAI	% Sensitive	% invasive	VIBI State	VIBI Category	Species Richness
Mitigation Wetlands of Management Concern	1622KR1	Krejci	DP	10/6/2014	4	12.0	26.1	0.2	46	Mod 2	12.8
	1622KR1	Krejci	DP	8/13/2018	4	11.8	31.0	0.3	49	Mod 2	17.5
	1627KR2	Krejci	DP	10/6/2014	4	11.0	0.1	1.3	29	1	21.0
	1627KR2	Krejci	DP	8/13/2018	4	12.2	0.0	0.5	51	Mod 2	22.0
	1079RS2	Rockside	DP	8/19/2015	4	6.2	0.0	20.7	12	1	12.5
	1079RS2	Rockside	DP	9/17/2019	4	9.0	0.1	51.6	13	1	14.5
	968PV968	Brookside / PV	DP	6/27/2008	4	9.2	0.0	66.3	13	1	24.8
	968PV968	Brookside / PV	DP	6/27/2018	4	3.0	0.0	97.7	7	1	6.5
Restoration Wetlands of Management Concern	977FP1	Fawn Pond	SP	7/31/2013	10	16.6	0.0	0.1	66	2	56.3
	977FP1	Fawn Pond	SP	9/15/2018	10	18.2	0.3	0.0	69	2	48.8
	977FP2	Fawn Pond	RM	8/8/2013	4	8.5	0.0	69.3	20	1	16.8
	977FP2	Fawn Pond	RM	9/14/2018	4	11.0	0.3	58.3	29	1	17.5
	977FP3	Fawn Pond	RM	9/11/2013	4	13.6	66.5	6.2	58	Mod 2	30.0
	977FP3	Fawn Pond	RM	9/13/2018	4	17.2	27.9	24.0	64	2	27.0
	977FP4	Fawn Pond	RM	9/11/2013	4	14.3	1.2	12.1	54	Mod 2	36.5
	977FP4	Fawn Pond	RM	9/11/2018	4	14.3	7.5	24.0	64	2	30.5
	977FP5	Fawn Pond	RM	8/12/2013	10	20.6	3.0	0.4	44	Mod 2	41.3
	977FP5	Fawn Pond	RM	9/11/2018	10	19.9	3.9	0.0	60	2	41.0
	969	Pleasant Valley	SP	9/10/2008	10	10.9	0.0	1.0	45	Mod 2	32.3
	969	Pleasant Valley	SP	6/26/2018	10	11.1	0.7	15.3	43	Mod 2	26.0
	970PV	Pleasant Valley	RM	9/24/2008	10	12.3	0.0	15.7	33	Mod 2	21.0
	970PV	Pleasant Valley	RM	7/5/2018	10	9.2	0.0	15.2	32	Mod 2	15.0
	1043	Pleasant Valley	SP	8/27/2008	4	8.3	0.0	90.4	23	1	18.3
	1043	Pleasant Valley	SP	6/27/2018	4	11.3	0.4	85.7	25	1	12.3
	1047	Pleasant Valley	RM	7/30/2008	4	7.5	0.0	82.8	13	1	9.5
	1047	Pleasant Valley	RM	6/25/2018	4	1.9	0.0	79.2	10	1	5.8
	1049	Pleasant Valley	RM	9/17/2008	10	15.8	25.7	0.7	30	Mod 2	39.0
	1049	Pleasant Valley	RM	6/28/2018	10	18.0	14.7	11.6	47	Mod 2	33.3
	540SF1	Stanford	RH	8/28/2015	4	3.9	0.0	96.7	10	1	6.3
	540SF1	Stanford	RH	9/4/2018	4	0.8	0.0	91.6	7	1	4.3
	540SF2	Stanford	RH	8/28/2015	4	5.6	2.4	91.4	7	1	9.0
	540SF2	Stanford	RH	9/7/2018	4	7.6	1.8	85.4	19	1	12.8
	540SF3	Stanford	RH	8/28/2015	4	2.0	0.0	99.8	10	1	2.8
	540SF3	Stanford	RH	9/7/2018	4	0.0	0.0	100.0	10	1	1.3
	540SF4	Stanford	RH	9/2/2015	4	3.7	0.0	67.0	13	1	7.5
	540SF4	Stanford	RH	9/6/2018	4	1.1	0.0	72.1	10	1	6.0

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 644/187453, January 2023

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525