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Natural Resource Stewardship and Science

Natural Resource Condition Assessment

Cuyahoga Valley National Park

Natural Resource Report NPS/CUVA/NRR—2021/2243

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ON THE COVER
Forest cove, Ledges area, Cuyahoga Valley National Park
Photograph by Dave Jones, Colorado State University

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Executive Summary

The National Park Service (NPS) Natural Resource Condition Assessment (NRCA) Program administered by the NPS Water Resources Division evaluates current conditions for important natural resources and resource indicators using primarily existing information and data. NRCAs also report on trends in resource condition when possible, identify critical data gaps, and characterize a general level of confidence for study findings. This NRCA complements previous scientific endeavors, is multi-disciplinary in scope, employs a hierarchical indicator framework, identifies and develops reference conditions/values for comparison against current conditions, and emphasizes spatial evaluation of conditions where possible.

Congress established Cuyahoga Valley National Park (CUVA) as a National Recreation Area in 1974 for the purpose of "preserving and protecting for public use and enjoyment, the historic, scenic, natural and recreational values" of the Cuyahoga Valley, thereby maintaining "needed recreational open space necessary to the urban environment". Public Law redesignated and renamed the unit Cuyahoga Valley National Park in 2000. The park totals approximately 33,000 acres, of which about 13,000 acres are in other public or private ownership. Congress directed park managers to use CUVA resources "in a manner, which will preserve its scenic, natural, and historic setting while providing for the recreational and educational needs of the visiting public."

The NRCA for CUVA employed a scoping process involving Colorado State University, Park and NPS staffs to establish the NRCA framework, identify important park resources, and gather existing information and data. Indicators and measures for each resource were then identified and evaluated. Data and information were analyzed and synthesized to provide summaries and address condition, trend and confidence using a standardized but flexible framework. A total of 11 resources were examined and included here: four addressing system and human dimensions, two addressing chemical and physical attributes, four addressing biological attributes, and one addressing an integrated resource assessment (wetlands). The quality and currentness of data used for the evaluation varied by resource. In general, data used were between 5–10 years old or older, but represented the most recent available data at the time.

Landscape context – system and human dimensions included land cover and land use, night sky, natural sounds, and climate change. Climate change and land cover/land use, which provide important context to the park and many natural resources and can be stressors on multiple resources, were not assigned a condition or trend. Land cover analyses incorporated spatial data for land cover classes, natural vs. converted land cover, impervious surfaces, population and housing trends and conservation (i.e., protection) status for buffer areas outside the park. The park is increasingly sandwiched between the urban centers of Akron and Cleveland; nearly 50% of the land area within 3 km of CUVA has been developed to some extent, and nearly 60% of the land within 30 km of the park boundary has been converted from natural land cover types. Climate change is happening and is affecting resources, but is not considered good or bad *per se*. Multiple local and regional effects on resources are anticipated. The condition of night skies and soundscapes, significantly altered by disturbance due to traffic, development and urbanization, both warrant significant concern and appear to be in further decline.

The supporting chemical and physical environment at the park include its air quality and water quality. The condition of these resources can affect human dimensions of the park such as visibility and visual resources as well as biological components such as vegetation health, human health and stream biota. Air quality warrants significant concern, while water quality warrants moderate concern. Conditions were estimated to be improving for both resources. Air quality and water quality in CUVA are significantly impacted by historical and current land uses outside the park boundary. Water quality in most tributaries to the Cuyahoga River that were evaluated have a majority (or the entirety) of the watershed outside the park boundary, limiting management options for the park and requiring the establishment of working relationships with other governmental and private entities.

The primary vegetation component examined consisted of upland and bottomland forests. The condition of both upland and bottomland forests warrants moderate concern. Forest resources at CUVA have been influenced by historical land uses that have changed the species composition and age structure of the forest. The park contains some of the largest remaining forest tracts in northeast Ohio, helping to support biodiversity as well as provide corridors for migratory wildlife species. Although large tracts of forests are found within the park, the majority of the forested areas are fragmented, and few areas within CUVA exhibit late-successional or old-growth characteristics. Those that do are at risk from multiple stressors. Condition metrics included invasive nonnative plants, forest pests and diseases, and native plant species composition. Forest communities at CUVA have a long history of being impacted by a variety of stressors and threats including noxious and invasive weeds, diseases and insect pests, compounding effects of climate change, air pollution, acid rain/atmospheric chemistry, past land uses, fire exclusion, and impacts associated with overabundant white-tail deer populations. These stressors and threats have collectively shaped and continue to impact forest community condition and ecological succession. The management of white-tail deer is anticipated to greatly benefit forest structure and composition in the future.

The faunal biological components examined included bats, birds, and fish. Birds (unchanging trend) and fish (improving trend) warrant moderate concern, while bat populations warrant significant concern and are in decline. The fragmentation of habitat and conversion of native vegetation to urban landscapes outside the park can negatively impact populations of some bats and birds at CUVA. The park contains some relatively unfragmented patches of habitat that provide refugia within an altered and urbanized regional landscape. Increased protection and restoration of caves, riparian forests and wetlands increase community abundance and diversity for bats and birds over time. Historical water quality degradation and restricted migration due to dams have and continue to be a challenge to fish conservation at the park. The fish community has responded positively as water quality has improved and numerous projects have been implemented, including native habitat restoration, reconnection of the floodplain to the river corridor, dam removal, barrier and impoundment bypass and removal, improved and comprehensive sewage treatment, and flow modifications within CUVA and the larger watershed.

Wetlands provide key habitat for numerous species and are sensitive to changes in water quality and hydrology. In general, wetlands at CUVA are in good condition with an unchanging trend. Although the condition of wetlands within CUVA has substantial room for improvement, wetlands are in good condition relative to those in Ohio and the upper Midwest as a whole.

The Cuyahoga River system is perhaps the single most important fundamental resource value in the park. When we examined results for focal resources related to the river ecosystem, four of five resources (water quality, bottomland forests, riparian birds and fish) warrant moderate concern. Water quality and fish resources were improving while birds and forests had overall unchanging trends. Wetlands were determined to be in good condition with an unchanging trend, although park staff indicate that the condition of wetlands in CUVA is improving. These results for the river system indicate that recent improvements in water quality within the watershed and recovery from the industrial era are resulting in a healthier river. However, the riparian and wetland habitat may need more time and effort to support the species that depend upon them.

The identification of data gaps during the course of the assessment is an important NRCA outcome. Resource-specific details are presented in each resource section. In some cases, significant data gaps contributed to the resource not being evaluated or low confidence in the condition or trend being assigned to a resource. Primary data gaps and uncertainties encountered were lack of recent survey data; uncertainties regarding reference conditions; availability of consistent, long-term data; and a need for more robust sampling designs.

Ecosystem stressors impacting park resources and their management exist both inside and outside park boundaries. Altered disturbance regimes such as fire and flooding, conversion and fragmentation of natural habitats, spread of invasive exotic plants that threaten regional biological diversity, altered hydrology and channel degradation of streams, and water pollution appear to be significant stressors of biological resources. Other resources that are related to human dimensions and visitation appeared to be stressed or directly affected by changes in land uses and land cover, population and housing densities, and traffic. Some of the resources were found to have interrelated stressors, the most common being invasive plants, environmental pollution, stream alteration and land-use development.

Regional and park-specific mitigation and adaptation strategies are needed to maintain or improve the condition of some resources over time. Success will require acknowledging a “dynamic change context” that manages widespread and volatile problems while confronting uncertainties, managing natural and cultural resources simultaneously and interdependently, developing broad disciplinary and interdisciplinary knowledge, and establishing connectivity across broad landscapes beyond park borders. Findings from the NRCA will help park managers to develop near-term management priorities, engage in watershed or landscape-scale collaboration and education efforts, conduct park planning, and report program performance.

Chapter 1. NRCA Background Information

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and resource indicators in national park units, hereafter "parks." NRCAs also report on trends in resource condition (when possible), identify critical data gaps, and characterize a general level of confidence for study findings. The resources and indicators emphasized in a given project depend on the park's resource setting, status of resource stewardship planning and science in identifying high-priority indicators, and availability of data and expertise to assess current conditions for a variety of potential study resources and indicators.

NRCAs Strive to Provide…

- *Credible condition reporting for a subset of important park natural resources and indicators*
- *Useful condition summaries by broader resource categories or topics, and by park areas*

NRCAs represent a relatively new approach to assessing and reporting on park resource conditions. They are meant to complement—not replace—traditional issue-and threat-based resource assessments. As distinguishing characteristics, all NRCAs:

- Are multi-disciplinary in scope;[1]
- Employ hierarchical indicator frameworks;[2]
- Identify or develop reference conditions/values for comparison against current conditions;[3]
- Emphasize spatial evaluation of conditions and GIS (map) products; [4]
- Summarize key findings by park areas; and [5]
- Follow national NRCA guidelines and standards for study design and reporting products.

Although the primary objective of NRCAs is to report on current conditions relative to logical forms of reference conditions and values, NRCAs also report on trends, when appropriate (i.e., when the underlying data and methods support such reporting), as well as influences on resource conditions. These influences may include past activities or conditions that provide a helpful context for

[1] The breadth of natural resources and number/type of indicators evaluated will vary by park.

[2] Frameworks help guide a multi-disciplinary selection of indicators and subsequent "roll up" and reporting of data for measures ⇨ conditions for indicators ⇨ condition summaries by broader topics and park areas

[3] NRCAs must consider ecologically-based reference conditions, must also consider applicable legal and regulatory standards, and can consider other management-specified condition objectives or targets; each study indicator can be evaluated against one or more types of logical reference conditions. Reference values can be expressed in qualitative to quantitative terms, as a single value or range of values; they represent desirable resource conditions or, alternatively, condition states that we wish to avoid or that require a follow-up response (e.g., ecological thresholds or management "triggers").

[4] As possible and appropriate, NRCAs describe condition gradients or differences across a park for important natural resources and study indicators through a set of GIS coverages and map products.

[5] In addition to reporting on indicator-level conditions, investigators are asked to take a bigger picture (more holistic) view and summarize overall findings and provide suggestions to managers on an area-by-area basis: 1) by park ecosystem/habitat types or watersheds, and 2) for other park areas as requested.

understanding current conditions, and/or present-day threats and stressors that are best interpreted at park, watershed, or landscape scales (though NRCAs do not report on condition status for land areas and natural resources beyond park boundaries). Intensive cause-and-effect analyses of threats and stressors, and development of detailed treatment options, are outside the scope of NRCAs.

Due to their modest funding, relatively quick timeframe for completion, and reliance on existing data and information, NRCAs are not intended to be exhaustive. Their methodology typically involves an informal synthesis of scientific data and information from multiple and diverse sources. Level of rigor and statistical repeatability will vary by resource or indicator, reflecting differences in existing data and knowledge bases across the varied study components.

The credibility of NRCA results is derived from the data, methods, and reference values used in the project work, which are designed to be appropriate for the stated purpose of the project, as well as adequately documented. For each study indicator for which current condition or trend is reported, we will identify critical data gaps and describe the level of confidence in at least qualitative terms. Involvement of park staff and National Park Service (NPS) subject-matter experts at critical points during the project timeline is also important. These staff will be asked to assist with the selection of study indicators; recommend data sets, methods, and reference conditions and values; and help provide a multi-disciplinary review of draft study findings and products.

NRCAs can yield new insights about current park resource conditions, but, in many cases, their greatest value may be the development of useful documentation regarding known or suspected resource conditions within parks. Reporting products can help park managers as they think about near-term workload priorities, frame data and study needs for important park resources, and communicate messages about current park resource conditions to various audiences. A successful NRCA delivers science-based information that is both credible and has practical uses for a variety of park decision making, planning, and partnership activities.

Important NRCA Success Factors

- *Obtaining good input from park staff and other NPS subject-matter experts at critical points in the project timeline*
- *Using study frameworks that accommodate meaningful condition reporting at multiple levels (measures ⇨ indicators ⇨ broader resource topics and park areas)*
- *Building credibility by clearly documenting the data and methods used, critical data gaps, and level of confidence for indicator-level condition findings*

However, it is important to note that NRCAs do not establish management targets for study indicators. That process must occur through park planning and management activities. What an NRCA can do is deliver science-based information that will assist park managers in their ongoing, long-term efforts to describe and quantify a park’s desired resource conditions and management targets. In the near term, NRCA findings assist strategic park resource planning[6] and help parks to report on government accountability measures.[7] In addition, although in-depth analysis of the effects of climate change on park natural resources is outside the scope of NRCAs, the condition analyses and data sets developed for NRCAs will be useful for park-level climate-change studies and planning efforts.

NRCAs also provide a useful complement to rigorous NPS science support programs, such as the NPS Natural Resources Inventory & Monitoring (I&M) Program.[8] For example, NRCAs can provide current condition estimates and help establish reference conditions, or baseline values, for some of a park's vital signs monitoring indicators. They can also draw upon non-NPS data to help evaluate current conditions for those same vital signs. In some cases, I&M data sets are incorporated into NRCA analyses and reporting products.

NRCA Reporting Products…

Provide a credible, snapshot-in-time evaluation for a subset of important park natural resources and indicators, to help park managers:

- *Direct limited staff and funding resources to park areas and natural resources that represent high need and/or high opportunity situations* ***(near-term operational planning and management)***
- *Improve understanding and quantification for desired conditions for the park's "fundamental" and "other important" natural resources and values* ***(longer-term strategic planning)***
- *Communicate succinct messages regarding current resource conditions to government program managers, to Congress, and to the general public* ***("resource condition status" reporting)***

Over the next several years, the NPS plans to fund an NRCA project for each of the approximately 270 parks served by the NPS I&M Program. For more information visit the NRCA Program website.

[6] An NRCA can be useful during the development of a park's Resource Stewardship Strategy (RSS) and can also be tailored to act as a post-RSS project.

[7] While accountability reporting measures are subject to change, the spatial and reference-based condition data provided by NRCAs will be useful for most forms of "resource condition status" reporting as may be required by the NPS, the Department of the Interior, or the Office of Management and Budget.

[8] The I&M program consists of 32 networks nationwide that are implementing "vital signs" monitoring in order to assess the condition of park ecosystems and develop a stronger scientific basis for stewardship and management of natural resources across the National Park System. "Vital signs" are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.

Chapter 2. Introduction and Resource Setting

2.1. Introduction

Cuyahoga Valley National Park is a partnership park, whereby an administrative boundary is superimposed on the landscape, encompassing a variety of land ownerships. The park totals approximately 33,000 acres, of which about 13,000 acres are in other public or private ownership. This arrangement presents significant challenges to park planning and management, necessitating cooperation and collaboration among landowners. Established in 1974, the park is relatively young, and recovery and restoration following centuries of land use, development and industrialization effects will take time. Therefore, resource condition trends may be more important than current condition (pers. comm. Lisa Petit, August 2015).

The park is surrounded by suburban and urban development; several Summit and Cleveland Metroparks exists within its boundary. Key partners include city, county and state parks; Countryside; The Conservancy for Cuyahoga Valley National Park (friends group); and the Ohio and Erie Canalway Association.

2.1.1. Enabling Legislation

The park purpose, significance statements, and legal and policy mandates guide the management of Cuyahoga Valley National Park. These mission and mandate statements define the parameters guiding management actions. All alternatives to be considered in the general management planning effort must be consistent with and contribute to fulfilling these missions and mandates.

Congress established Cuyahoga Valley National Park (CUVA) as a National Recreation Area in 1974 for the purpose of “preserving and protecting for public use and enjoyment, the historic, scenic, natural and recreational values” of the Cuyahoga Valley, thereby maintaining “needed recreational open space necessary to the urban environment”. Public Law redesignated and renamed the unit Cuyahoga Valley National Park in 2000 (NPS 2013). Congress directed park managers to use CUVA resources “in a manner, which will preserve its scenic, natural, and historic setting while providing for the recreational and educational needs of the visiting public.”

2.1.2. Geographic Setting

Located in northeast Ohio between the metropolitan areas of Cleveland and Akron, Cuyahoga Valley National Park (CUVA) protects 33,000 acres along the banks of the Cuyahoga River (Figure 2.1-1). The winding Cuyahoga—the “crooked river,” as named by Native Americans—gives way to floodplain terraces, steep valley walls and ravines, and lush upland forests. The park is a refuge for flora and fauna and provides both recreation and solitude for visitors and residents of the region (NPS 2013).

2.1.3. Park Significance[1]

The following significance statements have been identified for Cuyahoga Valley National Park:

[1] Adapted from NPS (2013)

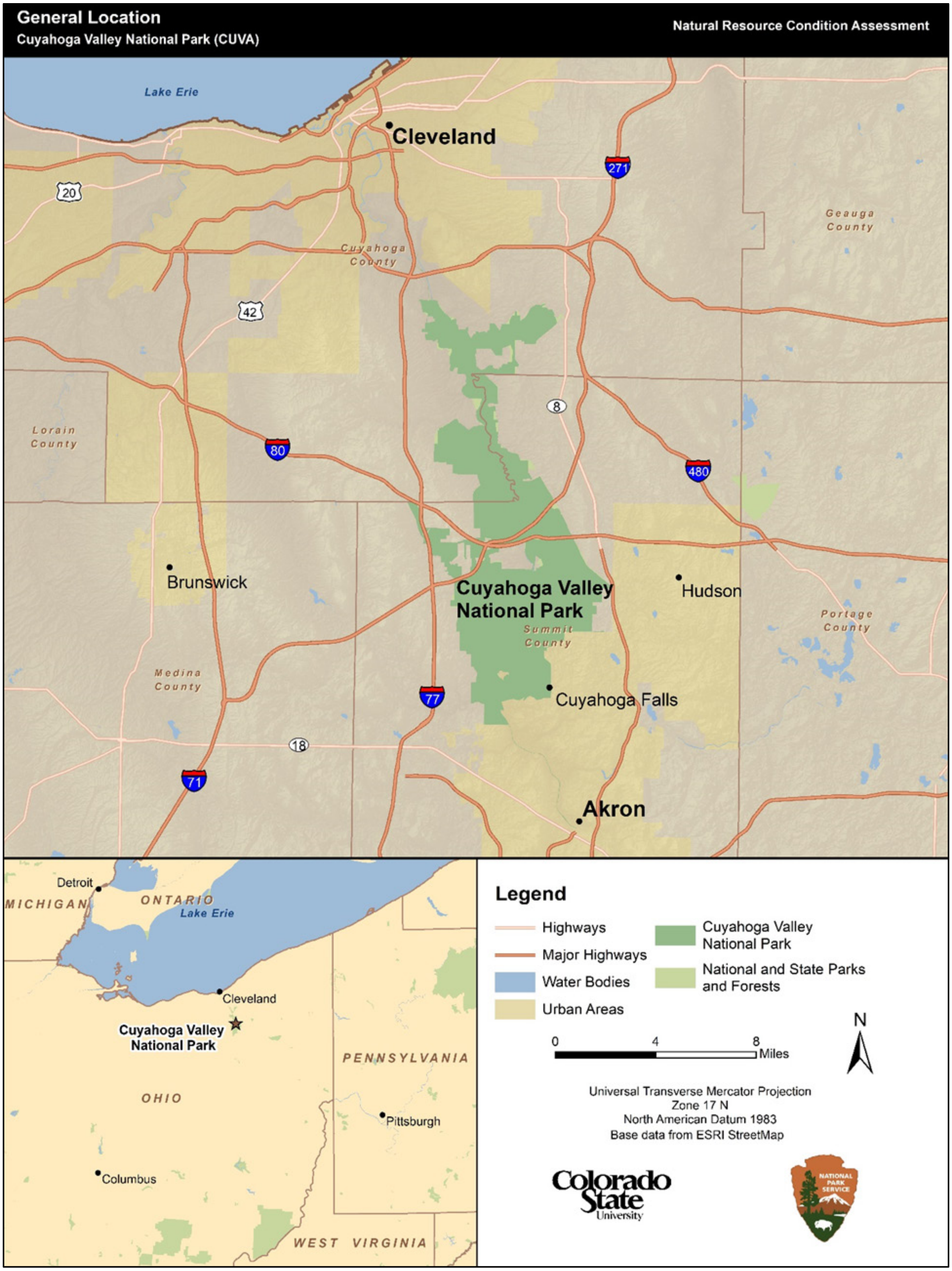

Figure 2.1-1. General location of Cuyahoga Valley National Park (base data from ESRI Streetmap and boundary from NPS).

- Cuyahoga Valley National Park is an island of high ecological integrity within a densely populated urban region. Situated along a major river system at the southern edge of Lake Erie, and bordering the edge of Ice Age glaciation between the Appalachian Mountains and the Great Plains, the park's location supports a high biological diversity and provides a vital habitat corridor for migrating species.
- Rooted in national environmental and social movements of the 20th century, the establishment of the park was a community-driven response to urban sprawl and ecological abuses epitomized by fires on the Cuyahoga River. The park continues to lead in restoring degraded landscapes, perpetuating environmental awareness, and promoting the ethic of stewardship and sustainability.
- Resources in the Cuyahoga Valley illustrate a continuum of transportation corridors from early American Indian to modern times. Of national significance, the Ohio & Erie Canal was part of the first interstate transportation system in lands known as the U.S. interior to the East Coast. This opened up the entire region for industrialization and contributed to the growth of the economy at a critical time in U.S. history.
- Cuyahoga Valley National Park protects a large and diverse collection of cultural resources in the Midwestern United States, consisting of more than 600 examples of historic structures, cultural landscapes, and archeological sites. This exceptional assemblage conveys themes that include American Indian and later settlement, transportation, agriculture, industry, and recreation.
- Cuyahoga Valley National Park came into being in 1974 as a unified patchwork of land ownership sewn together by an unprecedented grassroots effort of community partners. As an outgrowth of this partnership origin, the park has become an innovator and a national leader in shared stewardship models through its dynamic community engagement, nationally recognized partnerships, and one of the largest volunteer programs in the country.
- Located within a one-hour drive of over three million people, Cuyahoga Valley National Park offers in-depth, active, and innovative education and recreation opportunities that can provide a first national park experience to a large urban audience. These experiences are exemplified by a large community-connected trail system, a residential environmental education center, a scenic railroad, and a network of sustainable farms.

2.1.4. Visitation Statistics

Park visitors are a mixture of recreation and non-recreation travelers and local residents. Annual park recreation visitation increased dramatically from 1992 to 1994, and has declined moderately since 1997 (Figure 2.1-2). Mean annual visitation for the five-year period ending 2017 was 2,245,548 recreation visitors. According to 2013 data, the most visited attractions are the Cuyahoga Valley Scenic Railroad, the Station Road Trailhead, and the Buckeye Trail. Monthly visitation is highest from April to October (Figure 2.1-3) (NPS 2018).

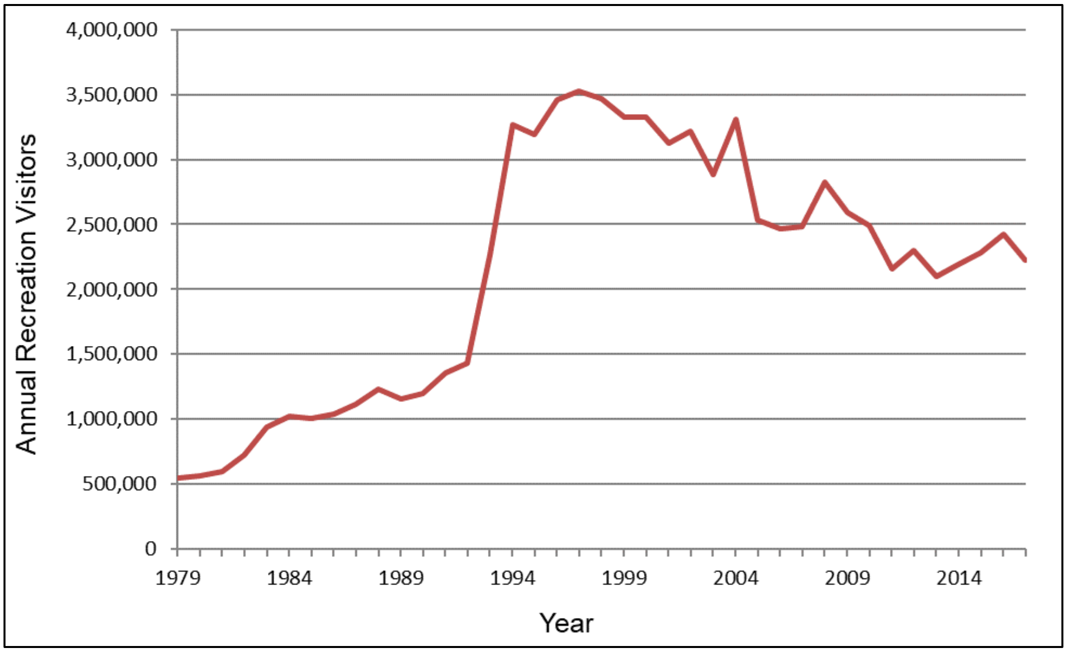

Figure 2.1-2. Annual CUVA recreation visitation for 1979–2017 (Data source: NPS 2018).

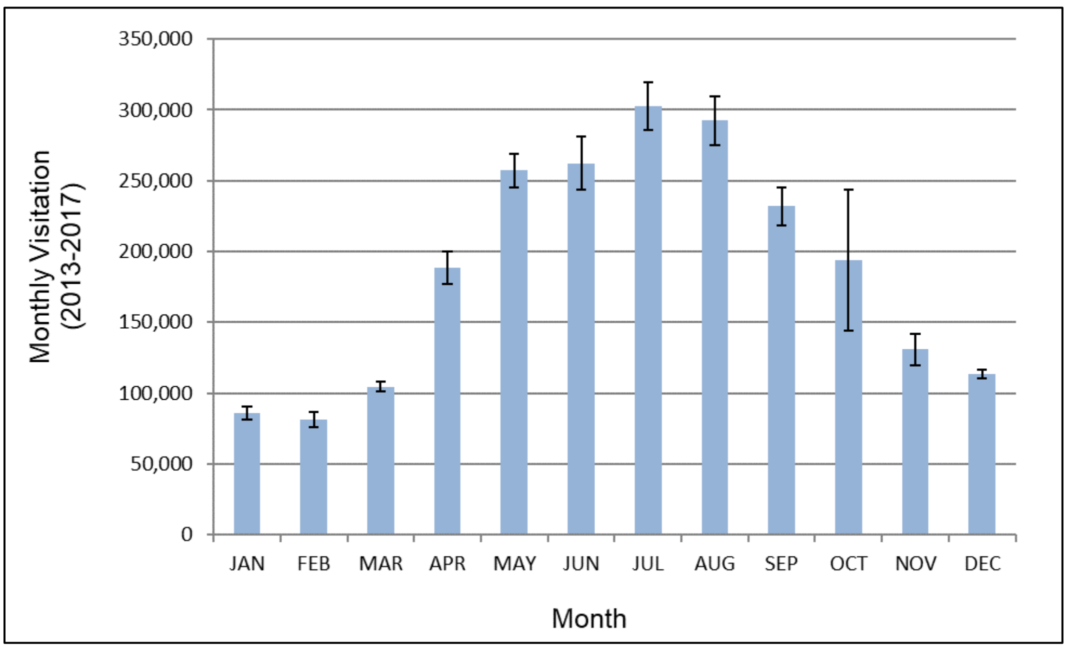

Figure 2.1-3. Means and 90% confidence intervals for monthly recreation visitation for CUVA for 2013–2017 (Data source: NPS 2018).

CUVA is considered a "travel park", overlapping the Ohio and Erie Canalway National Heritage Area and containing the Cuyahoga Valley Scenic Railroad and the Ohio and Erie Canal Towpath Trail. Most visitors use the towpath trail for biking, walking, running. Many visitors are locals or from metro areas to the north (Cleveland) and south (Akron). There is good and improving connectivity to other regional recreational trails.

2.2. Natural Resources

2.2.1. Ecological Units

Eastern Ohio is part of the Allegheny Plateau physiographic section that is further subdivided into a glaciated region to the north and an unglaciated region to the south. CUVA lies within this glaciated region in northeastern Ohio and is part of the Erie Drift Plain Level III ecoregion (see map in Section 4.7.1) (Omernik 1987).

Level IV ecoregions include the Low Lime Drift Plain (61c), Erie Gorges (61d), and with just 214 discontinuous acres at the south end of the park, the Summit Interlobate Area (61e) (Woods et al. 2003). The Low Lime Drift plain is characterized by a rolling landscape with occasional glacial moraines and kettles, and is distinct from the unglaciated and hilly country to its south. The Erie Gorges ecoregion is a steep and highly dissected area atypical of the region, with local relief sometimes exceeding 500 feet. Rocky outcroppings occur in this area and fluvial erosion rates are higher than surrounding areas (Woods et al. 2003).

At the habitat level, a vegetation inventory and mapping project at CUVA (Hop et al. 2013) mapped 29 map classes representing 44 natural or semi-natural vegetation associations from the United States National Vegetation Classification (USNVC). Approximately 74.4% (~24,000 acres) of CUVA was mapped as forest with 42.6% (~10,000 acres) of the forest representing successional forest types and 57.4% (~14,000 acres) representing non-successional forest types. Upland forest accounted for ~87% of the total CUVA forest and bottomland or riparian forest represented ~13% of the total forest (Hop et al. 2013). See section 4.7 (*Forests*) for more information on plant community types at CUVA.

2.2.2. Resource Descriptions

<u>Climate</u>

The climate at CUVA is influenced by its proximity to the Great Lakes; summers tend to be hot and humid, winters are cold, windy, and snowy, and spring and fall are mild with moderate temperatures (NCDC 2018; Figure 2.2-1). The average annual temperature at CUVA is 10.8° Celsius (C) (51.5° Fahrenheit (F)). The coldest month is January, with an average temperature of −2.7° C (27.2° F). The warmest month is July, with an average temperature of 23.4° C (74.1° F). The median growing season length at CUVA is 217 days with a last spring frost occurring around April 9 and a first fall frost occurring around November 11 (MRCC 2018). The typical snow season at CUVA spans October to April and averages 122 cm (48 in) of snowfall annually (MRCC 2018). The regional climate and projected changes to climate in the vicinity of the park are discussed in Chapter 4.4.

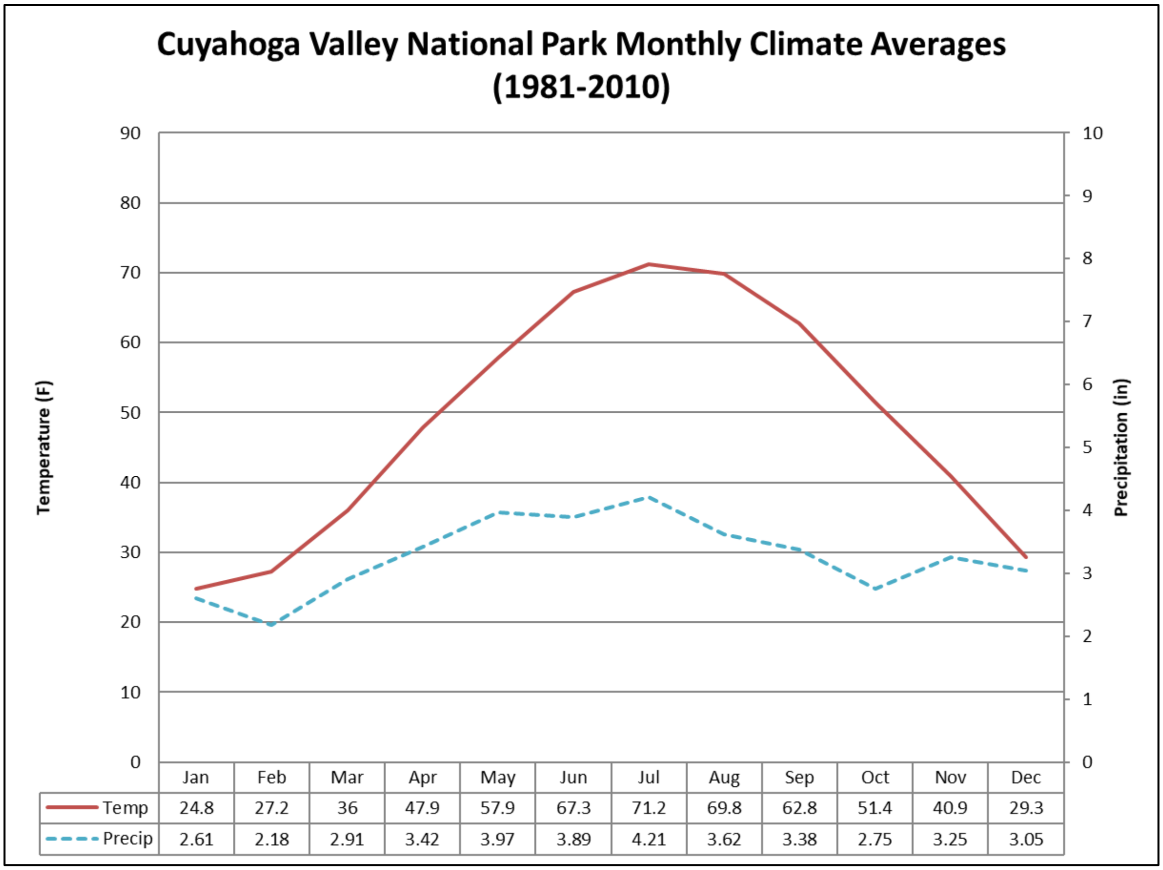

Figure 2.2-1. Walter climate diagram of Cuyahoga Valley National Park 30-year temperature and precipitation averages (1981–2010) (Data source: NCDC 2018).

Geology and Soils[2]

The main natural feature at CUVA is the Cuyahoga River Valley. The Cuyahoga River drains more than 800 square miles of glaciated terrain, but only 6.5% of this watershed is within CUVA. Valley walls and tributary ravines characterize the watershed with steep forested slopes rising 100 to 600 feet above the floodplain. The soils at CUVA were formed during glaciations of the Allegheny Plateau. Soils tend to be clay-like and unstable with most being poorly drained. Subsoil is often alkaline.

Hydrology and Watersheds[2]

The entirety of the park is contained within the Cuyahoga River Watershed. The park protects a complex of fluvial landforms, including a 22-mile corridor of the Cuyahoga River, its floodplain, and adjacent ravines that contain nearly 200 miles of perennial tributaries. Water quality in the Cuyahoga River has been historically poor, but is gradually improving, although segments of the river are still on the Clean Water Act's 303(d) list of impaired waters. Flood control and hydropower dams have altered natural flow regimes of the Cuyahoga River. Most park streams meet the warm water habitat

[2] Adapted from Middlemis-Brown and Young (2012)

standards set by the State of Ohio. Many park wetlands are affiliated with these surface waters, but there are also many wetlands created by groundwater seeps on slopes and other sources. The park has identified nearly 1,490 wetlands of varying size within its boundaries, encompassing approximately 1,900 acres. The most common types of wetlands at CUVA are wet meadow, marsh, scrub/shrub, and forested wetland.

Air Quality

Cuyahoga Valley National Park, like all the other parks within the Heartland Inventory & Monitoring network, is designated as a Class II airshed by the Clean Air Act of 1997 (Middlemis-Brown and Young 2012). As such, air quality within the park is protected to a less stringent degree compared to some other parks and protected areas around the country. Air quality at CUVA is not directly measured within the historic park but instead inferred from instrumentation located around the region.

The air quality parameters estimated for CUVA reflect regional air quality characteristics. For example, the wet and dry deposition of nitrogen and sulfur for CUVA reflects industrial land use from the north (which has a long history of coal power) and the agricultural character of central Ohio. Ozone concentrations generally mirror regional conditions and indicate significant impairment. These specific resource issues as well as visibility are addressed later in the document, have consequences for the health and condition of natural communities, human health and the quality of the visitor experience.

Land Use

Cuyahoga Valley National Park is located between two large metropolitan areas and includes land that was reclaimed from human development and agriculture. Northeastern Ohio was once mostly unbroken deciduous forest, and the land supporting this ecosystem was desirable to settlers seeking agricultural lands and timber resources. The valley briefly served as the edge of the newly formed United States when the 1795 Treaty of Greenville established the Cuyahoga River as the western boundary for settlement of the United States. By the mid-19th century, farms and villages dotted the valley landscape.

Land use patterns vary between the upper and lower basins of the Cuyahoga River. The upper basin is primarily used for agricultural, contrasting with the lower basin (where CUVA is located), which is one of the most densely-populated and industrialized areas in Ohio. The waters of the high-population areas in the middle and lower basin of the river are heavily polluted due to combined sewer overflows, construction site runoff, and land disposal (CRCPO 2011). Dominant agricultural uses include row cropping of corn and soybeans, hay and pasture.

Wildlife[2]

Animal species documented in the park include 241 species of birds, 91 aquatic invertebrates, 64 fish, 39 mammals, 20 amphibians, and 20 reptiles. In addition, 61 butterfly species have been documented. At least 10 bird species are of conservation concern nationally or regionally, and they are considered priority species by the international conservation consortium, Partners in Flight. Federally protected bald eagles have nested at the park since 2006 and have fledged several offspring in recent years; non-breeding eagles are often observed perched on trees near the Cuyahoga River during winter months. Whitetail deer have been studied for their impact on forests and vegetation (NPS 2014b).

Federally listed threatened, endangered, or candidate animal species: The presence of the federally listed endangered Indiana bat was documented in 2002 during a HTLN inventory (Krynak et al. 2005).

Ohio state-listed animal species: Sixteen observed bird species are listed as threatened or endangered (ODNR 2017), although many of these species are transients that do not breed in the park. One mammal and two turtles are state-listed species documented to occur in the park.

Vegetation[2]

CUVA supports a variety of habitats, but forest dominates vegetation cover. Mixed forests cover approximately 27,000 acres (80 percent) of CUVA with the oak-hickory association being the most common. Other common forest associations at the park include maple-oak, oak-beech-maple, maple-sycamore, pine-spruce, and hemlock-beech. A long history of intensive land use has created forests at CUVA with vastly different ages and community structures. Interspersed among forests are grasslands (approximately 2,000 acres or 6 percent of CUVA), wetlands (approximately 1,900 acres or 6 percent of CUVA), open water (approximately 150 acres or about 0.5 percent of CUVA), and agricultural land (approximately 1,300 acres or 4 percent of CUVA).

The forests of CUVA can be broadly categorized as upland or bottomland, based on landscape position. In upland forests, the dominant vegetation is a mix of hardwood trees, mainly oaks (*Quercus* spp.), hickories (*Carya* spp.), maples (*Acer* spp.), and American beech (*Fagus grandifolia*). Groundcover in upland forests can be sparse, consisting of mayapple (*Podophyllum peltatum*), trout lily (*Erythronium americanum*), spring beauty (*Claytonia virginica*), violets (*Viola* spp.), Jack-in-the-pulpit (*Arisaema triphyllum*), and other herbaceous species. Shrub cover in upland forests at CUVA also is typically sparse but, when present, often is dominated by maple-leaved viburnum (*Viburnum acerfolium*), spicebush (*Lindera benzoin*), and witchhazel (*Hamamelis virginiana*).

The largest and oldest bottomland forests are located in floodplains of the Cuyahoga River and its tributaries, and typically support an overstory of ashes (*Fraxinus* spp.), eastern cottonwood (*Populus deltoides*), sycamore (*Platanus occidentalis*), box elder (*Acer negundo*), Ohio buckeye (*Aesculus glabra*), silver maple (*Acer saccharinum*), and red maple (*Acer rubrum*). Herbaceous groundcover is more abundant in bottomlands than uplands with common species including enchanter's nightshade (*Circaea lutetiana*), bluegrass species (*Poa spp.*), sedges (*Carex* spp.), violets (*Viola* spp.), moneywort (*Lysimachia nummularia*), wingstem (*Verbesina alternifolia*), smartweed (*Polygonum* spp.), jewelweed (*Impatiens* spp.), wild leeks (*Allium tricoccum*), and garlic mustard (*Alliaria petiolata*). Shrub cover is sparse or more frequently absent in these areas. When present, bottomland shrubs consist mainly of viburnums (*Viburnum* spp.), non-native honeysuckles (*Lonicera* spp.), common privet (*Ligustrum vulgare*), and multiflora rose (*Rosa multiflora*).

Open fields are dominated by grasses (e.g., orchard grass (*Dactylis glomerata*), bluegrass, and switchgrass (*Panicum virgatum*) with many forbs present as well (e.g., goldenrods (*Solidago* spp.), dogbane (*Apocynum* sp.), and asters (family *Asteraceae*). Many fields at CUVA are mowed and support few woody plants. Previously cultivated old fields support more woody growth, including extensive stands of common privet, multiflora rose, and autumn olive (*Elaeagnus umbellata*). Early successional trees, such as eastern cottonwood and ashes, also may be present. Shrub-scrub habitats are dominated by dense stands of shrubs and saplings with a few taller trees scattered throughout. Common species in shrub habitats include hawthorn (*Crateagus* sp.), dogwood (*Cornus* spp.), viburnums, common privet, multiflora rose, and autumn olive.

Federally listed threatened, endangered, or candidate plant species: No federally listed plant species occur in the park.

Ohio state-listed plant species: Thirty-three plant species in the park are listed as state endangered (6 species), threatened (9 species), or potentially threatened (18 species), and inhabit forests, grasslands, and wetlands.

Ethnographic Resources[3]

The earliest known humans that lived in the Cuyahoga Valley about 13,000 to 11,000 years ago were Paleoindians. In contrast to the meager evidence for Paleoindians in the Cuyahoga Valley, is a relative wealth of Archaic evidence dating from 12,500 to 3000 B.P. Over the long Archaic period, the number of habitation sites steadily increased with the largest and densest occupations taking place during the Late Archaic stage. Following a transition period, the Archaic cultures gave way to more culturally complex Adena and Hopewell peoples in the Early and Middle Woodland periods between about 3000 and 1500 B.P. These cultures employed domesticated cultivation and constructed mounds and earthworks, including small, hilltop enclosures on the highlands above the Cuyahoga Valley. These hilltops enclosures were used for ceremonial purposes by the occupants of nearby villages and as season habitations. During five centuries of the Late Woodland era that followed, populations appear to have increased and larger groups made use of both upland and lowland resources. Beginning around 1000 B.P. distinct cultural changes took place in the Cuyahoga Valley, including the formation of seasonal village settlements and hilltop village sites during the Late Woodland period. All this came to an end about 350 years ago when the last remaining pre-contact tribal groups abandoned northeast Ohio in the face of epidemics and warfare. Not until the mid-1700s were other refugee Native American groups such as the Wyandot, Ottawa, and Mingo able to resettle in the Cuyahoga Valley and establish several well-known village sites, which were often occupied by an amalgam of groups until final dispossession at the turn of the 19th century.

Historical Features[2]

In 1996, legislation created the Ohio & Erie Canalway, a 110-mile national heritage area from Cleveland to New Philadelphia that extends the Towpath Trail and Cuyahoga Valley Scenic Railroad. The Canalway physically connects CUVA to local parks and approximately 40

[3] Adapted from Finney (2002) and Redmon (2006)

communities. The List of Classified Structures (LCS) for CUVA includes 320 buildings and structures that meet National Register of Historic Places (NRHP) requirements individually or contribute to a site or district. The park expects to add structures to the inventory as work continues in the park to find properties that meet the guidelines for evaluation.

2.2.3. Resource Issues Overview

Regional stressors that can impact park resources and their management include altered disturbance regimes such as conversion and fragmentation of natural habitats, spread of invasive exotic plants and animal species that threaten regional biological diversity, loss of native pollinators, excess deer browsing, and altered hydrology and pollution of waterways (Middlemis-Brown and Young 2012, NPS 2013). Management concerns highlighted in the park Foundation Document (NPS 2013) and by park staff during the scoping process consist of natural and cultural resource-related issues as well as stressors from outside the park. Major concerns and challenges are briefly described below.

Cuyahoga River Ecosystem

As the largest stakeholder in the recovery of the Cuyahoga River watershed, the park's 228 miles of river, streams, canal, floodplains, and more than 1,500 identified wetlands together provide an ecological buffer against impacts of development as the river connects to the Great Lakes Region ecosystem (NPS 2013). Water quality in the Cuyahoga River has historically been highly impaired. Infamously known as "the river that burned", fires had ignited numerous times on the Cuyahoga River in Cleveland. The last such fire in June 1969 helped to spur the environmental movement and environmental legislation in United States. Although the water quality of the river has improved greatly in recent decades, water quality and ecological health of the river, both of which affect recreational uses of the river, remain primary management concerns for the park (NPS 2013).

NPS lands provide some of the least impacted stream habitat remaining in the Midwest and streams at CUVA offer quality habitat for native fishes (Williams 2009). Because of the rarity of undisturbed non-urban and non-agricultural landscapes in the region, CUVA is especially valuable by providing relatively undisturbed stream and river habitat critical for sustaining native fishes within a highly altered landscape (Dodd et al. 2008). Additional impacts to the Cuyahoga River Ecosystem in relation to bottomland forests, invasive plant species, and wetlands are further described below.

Forest Ecosystem[2]

Cuyahoga Valley National Park contains some of the largest remaining stands of deciduous and mixed forests in the Northeastern Ohio region. It also supports biodiversity, providing corridors for migratory species and serving as a biological refuge in the context of development and climate change (NPS 2013). Although in relatively good condition for the region, forest ecosystems at CUVA are highly fragmented due to historic disturbances, roads, rights-of-way, and private land uses. The forest ecosystem at the park is also threatened by invasive plant and animal species, as well as deer overabundance (NPS 2013).

Invasive Nonnative Plants[2]

Nonnative invasive plants have been introduced and have spread throughout the region via agriculture and other human disturbances and practices. Invasive exotic plants are of concern at

CUVA because of their potentially detrimental effects on numerous vegetation communities and associated wildlife habitat. More than 1,200 plant species have been documented at CUVA with nearly 20 percent of those species being non-native to the area; approximately 50 of those non-native species are considered to be locally invasive and are able to over-run native habitats, displace native species, and form large monocultures that provide limited habitat value to native wildlife.

The most common invasive plants at CUVA include multiflora rose (*Rosa multiflora*), garlic mustard (*Alliaria petiolata*), reed canarygrass (*Phalaris arundinacea*), black locust (*Robinia pseudoacacia*), Japanese knotweed (*Polygonum cuspidatum*), privet (*Ligustrum spp.*), Japanese barberry (*Berberis thunbergii*), common reed (*Phragmites australis*), glossy buckthorn (*Frangula alnus*), Kentucky bluegrass (*Poa pratensis*), and autumn olive. These species are distributed throughout the park and frequently exhibit broad environmental tolerances that enable them to inhabit upland and bottomland forests, as well as old fields and scrub. Some invasive plants dominate wetland and riparian areas (e.g., reed canarygrass, Japanese knotweed, and common reed), while others (e.g., black locust and autumn olive) occupy drier uplands.

<u>Wetlands</u>

Most wetlands in the Cuyahoga River watershed are in good condition. The highest rates of degradation are documented in wetlands within the lower sub-basin of the Cuyahoga River, which includes CUVA (Fennessy et al. 2007). The protected landscape provides an important buffer for dozens of small watersheds that flow into the lower Cuyahoga River. CUVA wetlands are an integral part of this landscape, intercepting, filtering, and recharging surface and groundwater as it flows from these upper watersheds outside of the park and into the mainstem Cuyahoga River system (Bingham et al. 2016).

The most commonly cited threat to wetlands in the region is adjacent land uses. Effects of adjacent land use on wetlands include but are not limited to: destruction of ecological buffer zones, hydrologic and habitat isolation, as well as runoff of pollutants and excessive nutrients from agricultural and other non-point source pollution sources (Davey 2006).

Another major wetland stressor is the filling of wetlands. Fill can consist of soil, concrete, brick (Davey 2006) as well as coal ash from coal-fired power plants, which can contain highly elevated levels of toxins (pers. comm. Sonia Bingham, 2015). The "no net loss of wetlands" policy established in the 1990s has largely stopped the practice of filling wetlands without proper mitigation and compensation, but legacy effects remain. Other stressors include trash dumping, hydrologic alteration by ditching and drainage tiling, off-road vehicle use, and other stressors (Davey 2006).

<u>Historical and Cultural Resources</u>

Three fundamental resources identified by CUVA related to historical and cultural resources are the Ohio and Erie Canal, Valley Railway, and agricultural/ rural landscapes (NPS 2013). The Ohio and Erie Canal, which is designated as a national heritage corridor, has been impacted by sedimentation, erosion, vegetation encroachment, freeze/thaw cycles, and high visitation. The watered section is degrading but provides freshwater habitat. Threats to the Valley Railway are similar to that of the canal, with lack of maintenance funding and natural processes such as weathering and erosion being primary stressors (NPS 2013).

Agricultural resources and cultural landscapes at CUVA are in a variety of condition. (NPS 2013). Properties within the purview of the Countryside Initiative Program and those lands under special use permits tend to be well-maintained and preserved, while field and lands that are not actively managed are declining in condition. Threats and stressors to these lands include ecological succession from lack of maintenance, lack of funding, natural weathering, flooding, and vandalism (NPS 2013).

2.3. Resource Stewardship

2.3.1. Management Directives and Planning Guidance

Each unit in the National Park System is required by the National Park Service Organic Act of 1916 to "conserve the scenery and natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations." The General Authorities Act in 1970 (as amended) reiterated the provisions of the Organic Act and emphasized that "these areas, though distinct in character, are united through their inter-related purposes and resources into one national park system as cumulative expressions of a single national heritage." It also re-emphasized the importance of "unimpaired" NPS resources for future generations. The enabling legislation establishes park purposes and legislatively authorized uses within a context of cultural and natural resources. The *National Park Service Management Policies* (NPS 2006) provides Service-wide guidance for Park System planning, land protection, natural and cultural resources management, wilderness preservation and management, interpretation and education, use of the parks, park facilities and commercial visitor services. All management and planning documents developed for the park must adhere to these overarching documents and other laws, Executive Orders and Director's Orders.

A number of important NPS documents guide the management of natural resources in the park. The park's *Foundation Document* (NPS 2013) is the primary planning document for Cuyahoga Valley National Park. This document provides a broad direction for all phases and elements of CUVA management. Other important documents guiding stewardship at CUVA include the *Environmental Assessment for Fire Management* (NPS 2014a), *Heartland Invasive Plant Management Plan and Environmental Assessment* (Middlemis-Brown and Young 2012), and the *Draft Trail Management Plan and Environmental Impact Statement* (NPS 2012). These broad and park-specific documents and management directives provide important information for identifying and characterizing focal resources and articulating resource reference conditions in this natural resource condition assessment.

2.3.2. Status of Supporting Science

Available data and reports varied significantly depending upon the resource topic. Much of the supporting baseline survey and monitoring data was collected through the ongoing Heartland Network of the Inventory and Monitoring (I&M) Program initiated in the early 2000s. The Heartland Network also supported requests for geospatial data. Landscape context information and aspects of human dimensions were greatly supported by national program staff such as the Natural Sounds and Night Skies Division (NSNSD), the national NPS Air Quality program, and the NPScape Project within the Inventory and Monitoring Program. Additional information and data were provided by the park, published and unpublished reports and articles, and other outside experts noted in the individual resource sections.

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Chapter 3. Study Scoping and Design

3.1. Preliminary Scoping

The initial phase of the study consisted of a series of meetings, conversations and collaborations between Colorado State University and NPS staff, including the Midwest Regional NPS Office, the Heartland I&M Network, park staff, Water Resources Division (NRCA proponent), and National I&M programs. Initial scoping consisted of reviewing the *Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program Vital Signs Monitoring Plan* (DeBacker et al. 2005) the CUVA *Foundation Document* (NPS 2013) and other documents in order to begin to understand the management and resource context for the park. Vital signs previously identified and prioritized for the park were the basis for a preliminary list of focal resources to support initial NRCA discussions with park and other NPS staff. A site visit and initial meetings took place August 25–26, 2015 at CUVA Headquarters. The purpose of the preliminary scoping meetings was to:

- establish contact and begin dialogue with key staff members;
- identify points of contact;
- provide an overview of NRCA purpose and process (for park staff);
- provide an overview of park context, administrative history and management concerns (for cooperators);
- discuss analysis framework, reporting scales/units, and rating system;
- identify and discuss priority/focal resources in support of framework development
- discuss key NRCA concepts including indicators and measures, threats and stressors, and reference conditions;
- identify and gather available data and information;
- identify sources of expertise inside and outside the NPS;
- define project expectations, constraints, and the need to balance depth vs. breadth; and
- review the assessment timeline.

Key constraints placed on the scope of NRCA development include the following:

- the assessment will provide a snapshot of a subset of park resources, as determined through the scoping process;
- some lower priority resources or those having little supporting data may not be fully examined to allow a more comprehensive analysis of higher-priority resources;

- the assessment will use existing information/data and not modeled or projected data, although limited analysis and data development may be undertaken where feasible (e.g., data to support views/scenery analysis)—future modeled data is only used in the climate change section; and
- assignment of condition ratings may be constrained by insufficient information or inadequately defined reference conditions.

3.2. Study Design

3.2.1. Indicator Framework, Focal Resources and Indicators

The NRCA framework used for CUVA is adapted from The Heinz Center (2008) (Table 3.2-1). The Heinz structure was identified in the NRCA guidance documents as a relevant framework that organizes indicators under each focal resource within broad groupings of ecosystem attributes related to: landscape context including system and human dimensions; chemical and physical components; biological components; and integrated systems. Although threats and stressors are described for each focal resource, the Land Cover and Land Use and Climate Change sections were added to address broad ecosystem-level processes and stressors affecting multiple resources. A total of 11 resources were examined and included here: four addressing system and human dimensions, two addressing chemical and physical attributes, four addressing biological attributes, and one addressing an integrated resource assessment.

Some resources identified as important to the park and desirable to include in the NRCA during the scoping phase were either not included as focal resources or were addressed in a brief fashion due to lack of information or data, poor understanding of their ecological role and significance in the landscape, their absence at the park, or lack of justification to include them as a focal resource. The latter case for eliminating resources considered to have a lower priority for inclusion also reflected realities related to balancing cooperator budget, breadth of the assessment across many resources and depth of analysis. The following resources were discussed and eliminated from full or partial treatment:

- **Visual Resources:** An NPS visual resources inventory was initiated in 2018, facilitated by NPS Air Resources Division. Several designated scenic overlooks are located on the Bedford Reservation lands and at Kendall Ledges. There is much suburban, exurban and rural residential development, commercial development, utility lines and right of ways, cell towers, roads and highways, and bridges impacting views. However, CUVA visitors have few opportunities for visitors to see sweeping landscape views due to the nature of visitors being in the valley and generally in or surrounded by tall forest. There may be opportunities for additional types of views such as enclosed, framed and canopied views. Opening up some vegetation along the river along the trail and other areas is intended to enhance scenery for trail users. There is a desire to incorporate views into the new Visitor's Center in the Boston Store area. Virginia Kendall Ledges unit has several viewpoints used by hikers primarily. A number of highly visible power transmission right-of-ways run through the park.

- **Amphibians**: Amphibians are recognized as a sensitive indicator of environmental quality, but little data exist at CUVA. Existing data comes from disparate sources and appears linked to site- or project-specific needs versus park-wide assessment. Some monitoring has been implemented by park staff. Additional data are associated with EPA and Great Lakes Areas of Concern Remedial Action Plan (RAP), amphibian monitoring implemented through the Great Lakes Basin Marsh Monitoring Program (5 CUVA sites), and data from two Amphibian Index of Biotic Integrity (AmphibIBI) reference sites (pers. comm. Sonia Bingham, December 2015).

- **Reptiles:** This was considered a low priority; there is limited data and few sensitive reptiles are present.

- **Waterfalls:** There are numerous waterfalls within the park and they are considered an iconic element within the park and the region. According to park staff, waterfalls have been inventoried but the authors were unable to obtain any spatial or non-spatial data. Aside from several well know falls such as Brandywine Falls, Blue Hen Falls, and Buttermilk Falls, most are small and in remote areas not easily accessed by the public. The park is very interested in inventorying this resource to document associated biodiversity and ecological integrity, determine management needs and promote visitation.

Some of these topics are mentioned briefly in Chapter 2 and may also be discussed in focal resource sections in Chapter 4.

Table 3.2-1. Cuyahoga Valley National Park natural resource condition assessment framework (adapted from The Heinz Center 2008).

Ecosystem Attributes	Focal Resource	Assessment Level	Indicators and Measures of Condition
Landscape Context – System and Human Dimensions	Land Cover and Land Use	Full	• Land cover/land use • Population and housing • Conservation/protection status
	Night Sky	Full	• All-sky light pollution ratio (ALR)
	Natural Sounds	Full	• Ambient noise levels • Anthropogenic sources of noise • Traffic volumes on nearby and park roads
	Climate Change	Limited	• Modeled temperature and precipitation vs. historic baseline • Aridity – Palmer index (historic) • Frost-free period historic vs. projected
Chemical and Physical	Air Quality	Full	• Level of ozone: human health risk and vegetative health risk • Atmospheric wet deposition of total N and total S • Visibility haze index

Table 3.2-1 (continued). Cuyahoga Valley National Park natural resource condition assessment framework (adapted from The Heinz Center 2008).

Ecosystem Attributes	Focal Resource	Assessment Level	Indicators and Measures of Condition
Chemical and Physical (continued)	Water Quality	Full	• Index of Biotic Integrity (IBI) • Modified Index of well-being (MIwb) • Invertebrate Community Index (ICI) • Coliform bacteria
Biological – Plants	Forest Communities	Full	• Community composition (Native Species Composition) • Invasive exotic plants (IEP % cover) • Floristic Quality Assessment (FQAI) and Mean Coefficient of Conservatism • Ohio Rapid Assessment Method (ORAM) Condition Ranking • White-tail deer population and associated impacts • Forest pests and diseases • Forest vulnerability to climate change
Biological – Animals	Bats	Limited	• Native species richness (S) • Occurrence and status of bat species of conservation concern
	Riparian Birds	Full	• Native species richness (S) • Bird index of biotic integrity (IBI) • Occurrence of bird species of conservation concern
	Fish	Full	• Native species richness • Fish index of biotic integrity (IBI) • Species of conservation value
Integrated	Wetlands	Full	• ORAM 5.0 scores by wetland type • VIBI scores

3.2.2. Reporting Areas

The reporting area for all resources varies by resource but is often the entire area within the park boundary. In some cases, indicators were analyzed using subsets based on geographic or ecological strata within the park, e.g., upland birds and riparian birds. The results for each subset was then combined into single park-wide condition and trend ratings for the resource. For several resources such as those capturing landscape context, the extent of the analysis extends outside park boundaries in a fixed or variable way.

3.2.3. General Approach and Methods

General Approach

This study employed a scoping process involving Colorado State University, Park and NPS staffs to discuss the NRCA framework, identify important Park resources, and gather existing literature and data for each of the focal resources. Indicators and measures to be used for each resource were then identified and evaluated indicators. All available data and information were analyzed and synthesized to provide summaries and address condition, trend and confidence. Condition ratings compared the current condition at the park to the reference condition when possible (see section 3.2.4). In some cases, due to interrelationships, a focal resource was used to help determine condition and/or trend for another focal resource.

Sources of Information and Data

Non-spatial data, published literature, unpublished reports and other grey literature related to conditions both inside and outside the park were obtained from myriad sources. The primary sources for park-specific resource data were park staff, the Heartland I&M Network (HTLN) staff, and the public access side of the IRMA (Integrated Resource Management Applications) web portal, which is intended as a "one-stop shop" for data and information on park-related resources. Park and HTLN staff were an invaluable source of knowledge regarding resources, stressors and management history and activities. State and federal agency reports and data were downloaded using the web or obtained from the park or other agency staff. Spatial data were provided by the park, the Heartland Network, the NPS Midwest Region Office and other sources. The NPS Inventory and Monitoring (I&M) program and Night Skies and Natural Sounds Division (NSNSD) also provided data to support the assessment. Primary data sources are described in each focal resource section. In some cases, existing data were reworked in order to make them more useful for analysis.

Subject Matter Experts

A number of subject matter experts were consulted while developing this assessment. Expert involvement included in-person and telephone meetings, correspondence, and reviews of preliminary resource drafts. The experts consulted for each focal resource are listed in the resource sections in Chapter 4.

Data Analyses and NRCA Development

Data analysis and development of technical sections followed NRCA guidance and recommendations provided by the NPS. Data analyses were tailored to individual resources, and methods for individual analyses are described within each section of chapter four. As one of the tenets of the NRCA framework, geospatial analysis and presentation of results is used where possible throughout the assessment. Periodic contact between the authors, park and other NPS staff and subject matter experts took place as needed to obtain additional data and information or collaborate on an analysis framework or approach or on the interpretation of results.

Final Assessments

Final drafts followed a process of preliminary draft review and comment by park staff and other reviewers. Reviewer comments were incorporated and addressed to improve the analysis within the limits of the NRCA scope, schedule and budget.

3.2.4. Rating Condition, Trend and Confidence

For each focal resource, a reference condition for each indicator is established and a condition rating framework presented. The condition rating framework forms the basis for assigning a current condition to each indicator. In some cases, current condition and trend may be based on data or information that is several or more years old. Condition may be based on qualitative, semi-quantitative or quantitative data. Trend is assigned where data exists for at least two time periods separated by an ecologically significant span or may be based on qualitative assessments using historical information, photographs, anecdotal evidence or professional opinion. It is not uncommon for there to be some correlation among indicators for a particular focal resource. In a few cases, the trend assigned to an indicator may be influenced by the data for a correlated indicator. For example, traffic trend data may influence the trend rating for anthropogenic noise levels.

The level of confidence assigned to each indicator assessed integrates the comfort level associated with the condition and/or trend rating assigned. A lower confidence (i.e., higher uncertainty) may be assigned where modeled data has considerable uncertainty or numerous assumptions, where changes may be small and no quantitative data is available, where statistical inference is poor (e.g., as is often the case where sample sizes are inadequate), where interannual or seasonal variability is very high or unknown, where detectability is difficult when monitoring (e.g., some plants and birds), where only several closely spaced data points are available for trend determination (e.g., invasive exotic plant sampling only several years apart and only 2 periods available), or where a very small proportion of the reference frame or population of interest is sampled (in time or space), which influences the representativeness of the sample (e.g., the timing and length of attended listening data for natural sounds analysis). Lack of information/data may result in an unknown condition rating, which is often associated with unknown trend and low confidence.

3.2.5. Symbology and Scoring[4]

This NRCA uses a standardized set of symbols to represent condition status, trend and confidence in the status and trend assessment (Table 3.2-2, Table 3.2-3). This standardized symbology provides some consistency with other NPS initiatives and reporting programs.

[4] Adapted from NPS-NRCA Guidance Update dated January 18, 2018 (NPS 2018).

Table 3.2-2. Standardized condition status, trend and confidence symbology used in this NRCA.

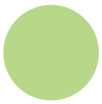
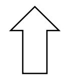
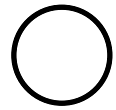
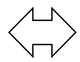
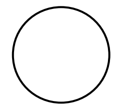
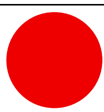
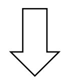
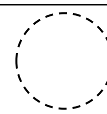
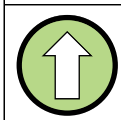
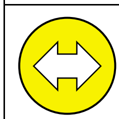
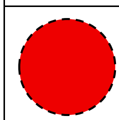
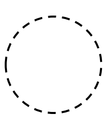
Condition Status		Trend in Condition		Confidence in Assessment	
Condition Icon	**Condition Icon Definition**	**Trend Icon**	**Trend Icon Definition**	**Confidence Icon**	**Confidence Icon Definition**
	Resource is in Good Condition		Condition is Improving		High
	Resource warrants Moderate Concern		Condition is Unchanging		Medium
	Resource warrants Significant Concern		Condition is Deteriorating		Low

Table 3.2-3. Examples of how condition symbols should be interpreted.

Symbol Example	Description of Symbol
	Resource is in good condition; its condition is improving; high confidence in the assessment.
	Condition of resource warrants moderate concern; condition is unchanging; medium confidence in the assessment.
	Condition of resource warrants significant concern; trend in condition is unknown or not applicable; low confidence in the assessment.
	Current condition is unknown or indeterminate due to inadequate data, lack of reference value(s) for comparative purposes, and/or insufficient expert knowledge to reach a more specific condition determination; trend in condition is unknown or not applicable; low confidence in the assessment.

The overall assessment of the condition for a focal resource may be based on a combination of the status and trend of multiple indicators and specific measures of condition. A set of rules was developed for summarizing the overall status and trend of a particular resource when ratings are assigned for two or more indicators or measures of condition. To determine the combined condition, each red symbol is assigned zero points, each yellow symbol is assigned 50 points, and each green symbol is assigned 100 points. Open (uncolored) circles are omitted from the calculation. Average scores of 0 to 33 warrant significant concern, average scores of 34 to 66 warrant moderate concern and average scores of 67 to 100 indicate the resource is in good condition. In some cases, certain indicators may be assigned larger weights than others when combining multiple metrics into a condition score. In those cases, the authors provide an explanation for the weights applied.

To determine the overall trend, the total number of down arrows is subtracted from the total number of up arrows. If the result is 3 or greater, the overall trend is improving. If the result is −3 or lower, the overall trend is deteriorating. If the result is between 2 and −2, the overall trend is unchanged. Sideways trend arrows and cases where trend is unknown are omitted from this calculation. Exceptions may be made when there are few indicators.

3.2.6. Organization of Focal Resource Assessments

Each focal resource section within chapter 4 has a similar organization.

Background and Importance

This section provides information regarding the relevance of the resource to the park and the broader ecological or geographic context. This section explains the characteristics of the resource to help the reader understand subsequent sections of the document. Relevant stressors of the resource and the indicators/measures selected are listed or discussed.

Data and Methods

This section describes the source and type of data used for evaluating the indicators/measures, data management and analysis (including qualitative) methods used for processing or evaluating the data, and outputs supporting the assessment

Reference Conditions

This section describes the reference conditions applied to each indicator and how the reference conditions are cross walked to a condition status rating for each indicator. NRCAs must use logical and clearly documented forms of reference conditions and values. Reference condition concepts and guidance is briefly described in Chapter 1. A reference condition is "a quantifiable or otherwise objective value or range of values for an indicator or specific measure of condition that is intended to provide context for comparison with the current condition values. The reference condition is intended to represent an acceptable resource condition, with appropriate information and scientific or scholarly consensus" (NPS 2018). An important characteristic of a reference condition is that it may be revisited and refined over time. The nature of the reference condition prescribed for a particular resource can vary with the status of the resource relative to historic conditions and anticipated future conditions (Figure 3.2-1).

For example, substantial overlap may exist for prairie vegetation, moderate overlap may exist for birds and little or no overlap may exist for nonnative invasive plants. Reference conditions can be particularly difficult to define where presettlement conditions or range of variability are unknown, and/or where little inventory and monitoring data exist.

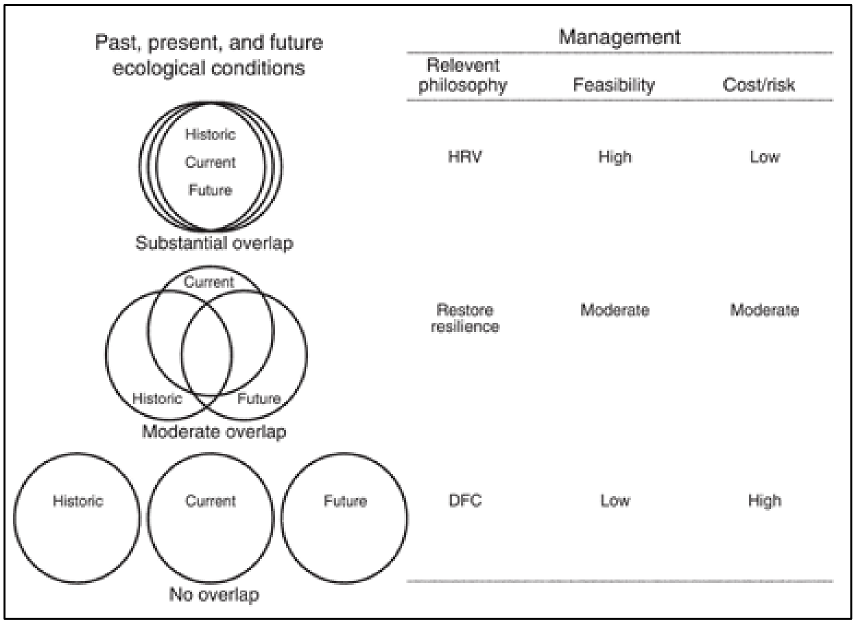


Figure 3.2-1. Illustration of three possible cases of the extent to which current ecosystem conditions in a place differ from historic conditions and from projected future conditions. Circles denote the range of variability for each time period. Also shown are the expected management criteria for each case. Abbreviations are HRV, historic range of variability and DFC, desired future conditions (Hansen et al. 2014).

Condition and Trend

This section provides a summary of the condition for each indicator/measure based on available literature, data, and expert opinions. A condition status, trend and confidence designation for each indicator/measure is assigned and accompanying rationale is provided. Where multiple indicators or metrics are used, a single rating is consolidated for each resource using the condition rating scoring framework described earlier in this chapter.

Uncertainty and Data Gaps

This section briefly highlights information and data gaps and uncertainties related to assessment of the focal resources.

Sources of Expertise

Individuals who were consulted or provided preliminary reviews for the focal resource are listed in this section.

Literature Cited

This section lists all of the referenced sources in this section.

3.2.7. Literature Cited

DeBacker, M.D., C.C. Young (editor), P. Adams, L. Morrison, D. Peitz, G.A. Rowell, M. Williams, and D. Bowles. 2005. Heartland Inventory and Monitoring Network and Prairie Cluster Prototype monitoring program vital signs monitoring plan. National Park Service Heartland I&M

Network and Prairie Cluster Prototype Monitoring Program, Wilson's Creek National Battlefield. Available at: https://irma.nps.gov

Hansen, A.J., N. Piekielek, C. Davis, J. Hass, D.M. Theobald, J.E. Gross, W.B. Monahan, T. Olliff and S. W. Running. 2014. Exposure of U.S. National Parks to land use and climate change 1900–2100. Ecological Applications, 24(3), 2014, pp. 484–502

National Park Service (NPS). 2013. Foundation Document, Cuyahoga Valley National Park. USDI National Park Service.

NPS. 2018. Natural resource condition assessment guidance documents and useful resources. NPS Water Resources Division. Available at: https://www.nps.gov/orgs/1439/nrca.htm

The H. John Heinz III Center for Science, Economics and the Environment (The Heinz Center). 2008. The state of the nation's ecosystems 2008: measuring the lands, waters, and living resources of the United States. Washington, D.C.

Chapter 4. Natural Resource Conditions

4.1. Land Cover and Land Use

This section places park resources and management concerns within a local and regional context of land cover and land use and examines implications related to population and resource conservation. Using several metrics, it characterizes conditions and dynamics of the surrounding areas, highlights the potential effects of related landscape-scale stressors on park resources, and underscores the conservation value of the park to the surrounding region. The synthesis of national data uses a series of straightforward spatial analyses for areas within and surrounding the park. Condition and trend ratings are not assigned to these landscape context metrics. In some cases, long-term data are not available and for the most part the park has little influence over activities occurring outside park boundaries. Longer-term data and future projections are available for some population and housing metrics.

4.1.1. Threats and Stressors

Land use is intensifying around many protected areas including parks and monuments (Wittemyer et al. 2008, Wade and Theobald 2010, Davis and Hansen 2011, Hansen et al. 2014). Many parks in the NPS Midwest Region are concerned with the ecological consequences of habitat loss associated with urbanization outside park boundaries, conversion of surrounding areas to non-natural uses, and the effects of runoff from impermeable surfaces on hydrologic flows through the parks (Hansen and Gryskiewicz 2003). The growth of housing adjacent to protected areas can create a patchwork of land use that degrades the conservation impact of high-value protected areas on adjacent parcels and within the region (Radeloff et al. 2010). Protected areas are most effective when they conserve habitat within their boundaries and are connected with other protected areas via intact corridors (Radeloff et al. 2010). According to the Radeloff et al. study, the main threat to protected areas in the U.S. is housing density, which is highly correlated with population density. The adverse effects of development also impact the quality of the natural environment and visitor experience related to night skies, natural soundscapes and viewscapes/scenery.

4.1.2. Indicators and Measures

Indicators of landscape context applied here include a variety of metrics for land cover and land use, population and housing, and land conservation status.

- Land cover and Use
    - Extent of Anderson Level II classes
    - Extent of natural vs. converted land cover
    - Extent of impervious surface area
- Human population and housing
    - Housing density
    - Historic population: total and density

    - Population: current and projected total and density

- Conservation status
    - Protected area (ownership) extent
    - Biodiversity conservation status (level of protection)

4.1.3. Data and Methods

Spatial data for land cover, population, and housing used for condition and trend analysis were provided by the NPS NPScape Program and follow protocols described in Monahan et al. (2012). Sources of other data are noted below.

Defining Areas of Interest

Landscape context elements were examined within several areas of interest, as landscape attributes important to park resources often vary with scale or spatial extent. Relevant scales or areas of analysis (AOAs) consist of the area within the park boundary, the "boundary" area immediately adjacent to the park extending 3 km from the administrative boundary, the local area surrounding the park (i.e., within 30 km of the park boundary), and the watershed area(s) upstream from the park contributing to streams within the park, and nearby counties. Areas of analysis and metrics used here are based on recommendations from Monahan et al. (2012) (Table 4.1-1). Contributing upstream watershed is included because it significantly influences water quality and watershed/hydrologic characteristics (Monahan and Gross 2012). Regional topography is relatively gentle (although there are some geological anomalies within the park), and climate is fairly uniform throughout the areas of interest.

Table 4.1-1. Areas of analysis used for land cover and land use measures (Monahan et al. 2012).

		Areas of Analysis			
Category	**Indicators and Measures**	**3 km buffer around park**	**Park + 30 km buffer**	**Contributing upstream watershed**	**Counties overlapping with park + 30 km buffer**
Land cover and use	Anderson Level II	X	X	X	–
	natural vs. converted land cover	X	X	X	–
	impervious surfaces	–	–	X	–
Human Population and Housing	population total and density by census block group (historic and projected)	–	X	–	–
	historic population totals by county	–	–	–	X
	housing density 1970–2010	–	X	X	–
Conservation status	Protected areas (ownership) and biodiversity conservation status	X	X	–	–

Land Cover

United States Geological Survey (USGS) National Land Cover Dataset (NLCD) data for 2011 was used to characterize current/recent conditions. NLCD data products are derived from Landsat Thematic Mapper (TM) imagery with a 30 m pixel resolution. NLCD summaries employ a well-documented, consistent procedure that is highly repeatable over time. Although NLCD data date back to 1992, differences in classification and analysis methods do not favor comparison of the 1992 data with 2011 data (Monahan et al. 2012). Procedures for the summarization of data for the following indicators are from NPS (2014a).

- **Anderson land cover/land use classes:** NLCD data were interpreted and classified using Anderson Level II land cover classes (Table 4.1-2) for the areas of analysis listed in Table 4.1-1.
- **Acreage of natural vs. converted land cover**: The NLCD Anderson Level I "developed" and "agriculture" classes were reclassified as "converted" (Table 4.1-2) and analyzed using the areas of analysis listed in 4.1-1. Other classes were classified as "natural".
- **Impervious surface area**: The NLCD Anderson Level I "developed" classes are reclassified as "impervious" and all other land cover classes were classified as "pervious" and analyzed using the areas of analysis listed in Table 4.1-1. Areas that are more impervious reduce the amount of water infiltration into the soil and local water tables, and contribute to altered hydrographs and flashier runoff characteristics.

Table 4.1-2. Anderson land cover/land use classes (Anderson et al. 1976) and rules for reclassifying Anderson land cover as natural vs. converted land cover.

Anderson Level I	Anderson Level II	Natural/Converted
Open Water	–	Natural
Developed	–	Converted
Barren/Quarries/Transitional	–	Natural
Forest	–	Natural
Shrub/Scrub	–	Natural
Grassland/Herbaceous	–	Natural
Agriculture	pasture/hay vs. cultivated agriculture	Converted
Wetlands	–	Natural

Human Population and Housing

Housing Density

Change from 1970 to 2010 and projected changes to 2050 were examined. The NPScape housing density metrics used here are based on the Spatially Explicit Regional Growth Model (SERGoM v3) (Theobald 2005). Housing density data are categorized into 11 non-uniform development classes and then reclassified as described by Theobald (2005): rural (0–0.0618 units/ha), exurban (0.0618–1.47

units/ha), suburban (1.47–10.0 unit/ha), and urban (> 10.0 units/ha). The non-uniform ranges permit a much finer delineation of areas of low-density housing than is common for non-ecological studies (Monahan et al. 2012).

Total Population and Population Density

Historical data were derived from county-level population totals from the U.S. Census Bureau for all counties overlapping with the 30 km park buffer. Population density was derived from U.S Census Bureau block data from 1990, 2000 and 2010. Population density (number of people per square kilometer) classes follow NPS guidance (NPS 2014b).

<u>Conservation Status</u>

The two primary sources of protected areas data were the Protected Areas Database-US (PAD-US) Version 2 from the Conservation Biology Institute (CBI 2013) and the National Conservation Easement Database (NCED 2013). The two databases are designed to be used together to show comprehensive protection status for areas of interest while using compatible database attributes such as ownership type and agency.

Ownership

Land ownership greatly influences the level of conservation protection. The PAD-US Version 2 (CBI Version 2) is a national database of protected fee lands in the United States. It portrays the United States protected fee lands with a standardized spatial geometry with their associated land ownership, management designations, and conservation status (using national GAP coding systems). The National Conservation Easement Database (NCED) Version III (July 2013) is a voluntary national geospatial database of conservation easement information that compiles records from land trusts and public agencies throughout the United States. It allows for the identification of all lands under conservation easements regardless of ownership. It is a collaborative partnership by the Conservation Biology Institute, Defenders of Wildlife, Ducks Unlimited, NatureServe, and the Trust for Public Land (NCED 2013). As of May 2013, the acreage of publicly-held easements is considered to be 28% complete for Ohio; the accounting of the acreage of NGO-held easements in Ohio is currently estimated at approximately 35% complete. The low percentage of completeness for NGO-held easements is because: 1) they have not been digitized, 2) they were withheld from NCED, or 3) the NCED team is still working with the easement holders to collect the information (http://www.conservationeasement.us/about/completeness).

Level of Protection

The USGS Gap Analysis Program (GAP) uses a scale of 1 to 4 to categorize the degree of biodiversity protection for each distinct land unit (Scott et al. 1993). A status of "I" denotes the highest, most permanent level of maintenance, and "IV" represents no biodiversity protection or areas of unknown status. The PAD-US (CBI Version 2) database includes the coded GAP biodiversity protection status of each parcel. The NCED database is designed to accommodate the GAP protection status field but most parcels have not been assigned a GAP conservation value. The four status categories are described below.

- **Status I**: These areas have permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, and intensity) are allowed to proceed without interference or are mimicked through management. Most national parks, Nature Conservancy preserves, some wilderness areas, Audubon Society preserves, some USFWS National Wildlife Refuges and Research Natural Areas are included in this class.

- **Status II**: These areas have permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive use or management practices that degrade the quality of existing natural communities. Some national parks, most wilderness areas, USFWS Refuges managed for recreational uses, and BLM Areas of Critical Environmental Concern are included in this class.

- **Status III**: These areas have permanent protection from conversion of natural land cover for the majority of the area, but may be subject to extractive uses of either a broad, low-intensity type or localized intense type. This class also confers protection to federally-listed endangered and threatened species throughout the area. Most non-designated public lands, including USFS, BLM and state park land are included in this class.

- **Status IV**: These areas lack irrevocable easement or mandate to prevent conversion of natural habitat types to anthropogenic habitat types. This class allows for intensive use throughout the tract, and includes those tracts for which the existence of such restrictions or sufficient information to establish a higher status is unknown. Most private lands fall into this category by default.

Protected areas data from the two databases were examined by owner type and by easement protection status within a 30 km buffer of the park boundary. GAP biodiversity protection values were summarized for NCED and PAD-US parcels by ownership type within the 30 km buffer areas of interest. There is some spatial overlap between the PAD-US and NCED databases due to the existence of easements on some lands owned by federal, state and local agencies. Where easements existed on these public (i.e., protected) lands, the acreages were reported by owner only to avoid double counting in the number of protected acres.

4.1.4. Condition and Trend

Land Cover and Use

Extent of Anderson Level II Classes 2011

In the immediate vicinity of CUVA (3 km buffer) over 38% of land acreage is deciduous forest cover, over 20% is "developed – open space", and over 18% is low intensity development (Table 4.1-3, Figure 4.1-1). Nearly 50% of the land area within 3 km of CUVA is developed. Within the 30 km buffer, over 23% of the acreage is deciduous forest, nearly 18% is open space, and 16% is low intensity development. Most areas classified as medium or high intensity development are associated with Cleveland and Akron. Land cover of the contributing upstream watershed of the park is 31%

deciduous forest and 18% developed, open space. Although the forests surrounding CUVA are fairly patchy and lack a high degree of connectivity, the patches are much larger than those surrounding most federal and state lands in the region (Figure 4.1-1).

Between 1959 and 2002, the vast majority of cropland and pasture inside what is now the park boundary was mostly converted to forest types, or wetlands in some specific locations. In the area within several miles of the park boundary, during this same time period the vast majority of crop and pasture land was converted to residential classes. Some forest was also converted to residential land use (unpublished land use data provided by Andrew Bishop, former CUVA Natural resources Specialist). Lack of documentation and consistency between the 1959 classification and the 2011 NLCD data precluded more detailed long-term analysis.

Table 4.1-3. Anderson Level 2 land cover classes within 3 km and 30 km of the park boundary, and within the contributing upstream watershed of the park (from National Land Cover Dataset data provided by NPS NPScape Program).

	3 km Buffer		**Park + 30km Buffer**		**Contributing Upstream Watershed**	
Anderson Level 2 Classes	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**
Barren Land	67	0.05%	1,417	0.10%	665	0.14%
Cultivated Crops	1,043	0.84%	135,662	9.73%	40,456	8.46%
Deciduous Forest	47,316	38.27%	322,242	23.11%	148,267	31.02%
Developed, High Intensity	3,607	2.92%	29,385	2.11%	9,740	2.04%
Developed, Low Intensity	22,797	18.44%	226,340	16.23%	77,764	16.27%
Developed, Medium Intensity	10,032	8.11%	83,020	5.95%	27,836	5.82%
Developed, Open Space	25,068	20.28%	248,460	17.82%	87,389	18.28%
Emergent Herbaceous Wetlands	88	0.07%	1,118	0.08%	797	0.17%
Evergreen Forest	1,404	1.14%	7,960	0.57%	3,800	0.79%
Hay/Pasture	3,836	3.10%	110,247	7.91%	39,315	8.22%
Herbaceous	3,009	2.43%	31,865	2.29%	15,365	3.21%
Mixed Forest	57	0.05%	494	0.04%	236	0.05%
Open Water	1,028	0.83%	166,040	11.91%	11,967	2.50%
Perennial Snow/Ice	0	0.00%	0	0.00%	0	0.00%
Shrub/Scrub	238	0.19%	2,260	0.16%	1,398	0.29%
Unclassified	0	0.00%	0	0.00%	0	0.00%
Woody Wetlands	4,045	3.27%	27,678	1.99%	13,053	2.73%
Total	**123,635**	**–**	**1,394,190**	**–**	**478,046**	**–**

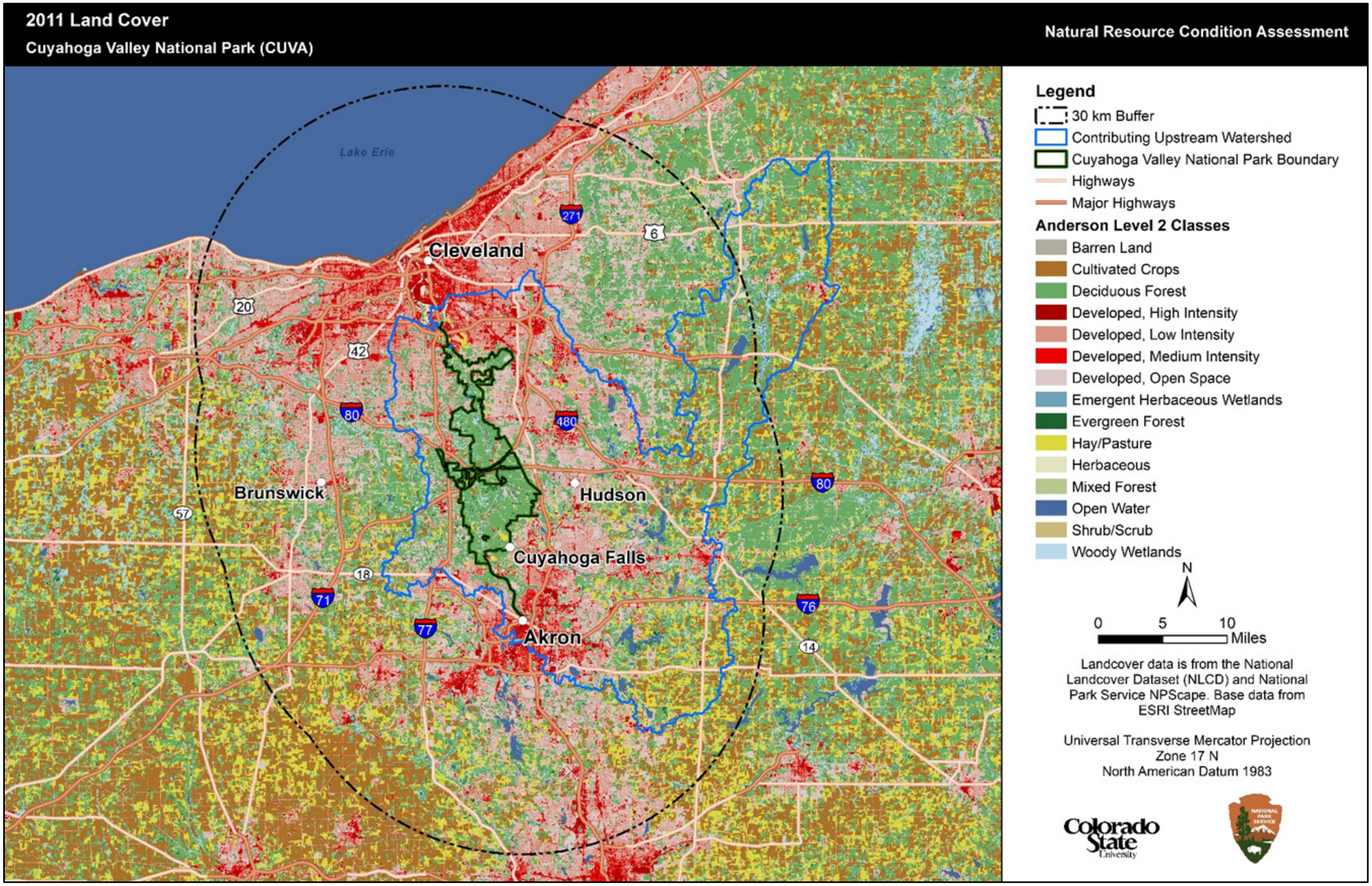


Figure 4.1-1. Anderson Level II land cover classes within 3 km and 30 km of the park boundary, and within the contributing upstream watershed of the park (National Land Cover Dataset data provided by NPS NPScape Program; base data from ESRI Streetmap).

Natural vs. Converted Land Cover

Change in natural land cover is perhaps the most basic indicator of habitat condition (O'Neill et al. 1997). Knowing the proportion of natural land cover area to converted land area provides a general indication of overall landscape condition, offering insight into potential threats and opportunities for future conservation. The proportion of converted acreage surrounding CUVA is similar for all AOA's (Table 4.1-4, Figure 4.1-2). Within 30 km of the park boundary, nearly 60% of the area is classified as converted, while 59% of the contributing upstream watershed is classified as converted (Table 4.1-4).

Table 4.1-4. Natural vs. converted acreage within 3 km and 30 km of the park boundary, and within the contributing upstream watershed of the park (from National Land Cover Dataset data provided by NPS NPScape Program).

	Natural		Converted	
AOA	**Acres**	**% of Area**	**Acres**	**% of Area**
3km	57,252	46.31%	66,383	53.69%
Park + 30km Buffer	561,077	40.24%	833,113	59.76%
Contributing Upstream Watershed	195,546	40.91%	282,500	59.09%

Impervious Surface Area

Impervious surfaces include bare rock, paved roads, and areas covered with concrete/cement. These surfaces prevent infiltration of precipitation into the ground. This reduced infiltration can cause significant hydrological effects including quicker runoff into streams and rivers resulting in flooding, more rapid rising and dropping of streamflow after precipitation events, reduced local evapotranspiration, and reduced recharge of local aquifers. Imperviousness can also increase aquatic pollution as contaminant transport is increased by water flowing directly to a stream or other water body without the opportunity for uptake or decomposition by plants and soil organisms.

Most of CUVA's contributing upstream watershed is in the lowest imperviousness class (0–2% impervious surfaces) (Figure 4.1-3, Table 4.1-5). There is a low degree of imperviousness in relation to other areas in the region. This is attributable to the fact that a significant portion of the surrounding acreage is forest, with a moderate amount of development in the area. As a benchmark for future analysis, approximately 20.6% of the contributing upstream watershed of the park was classified as having >25% impervious surfaces (Table 4.1-5), the vast majority of which is concentrated near the cities of Akron and south of Cleveland (Figure 4.1-4).

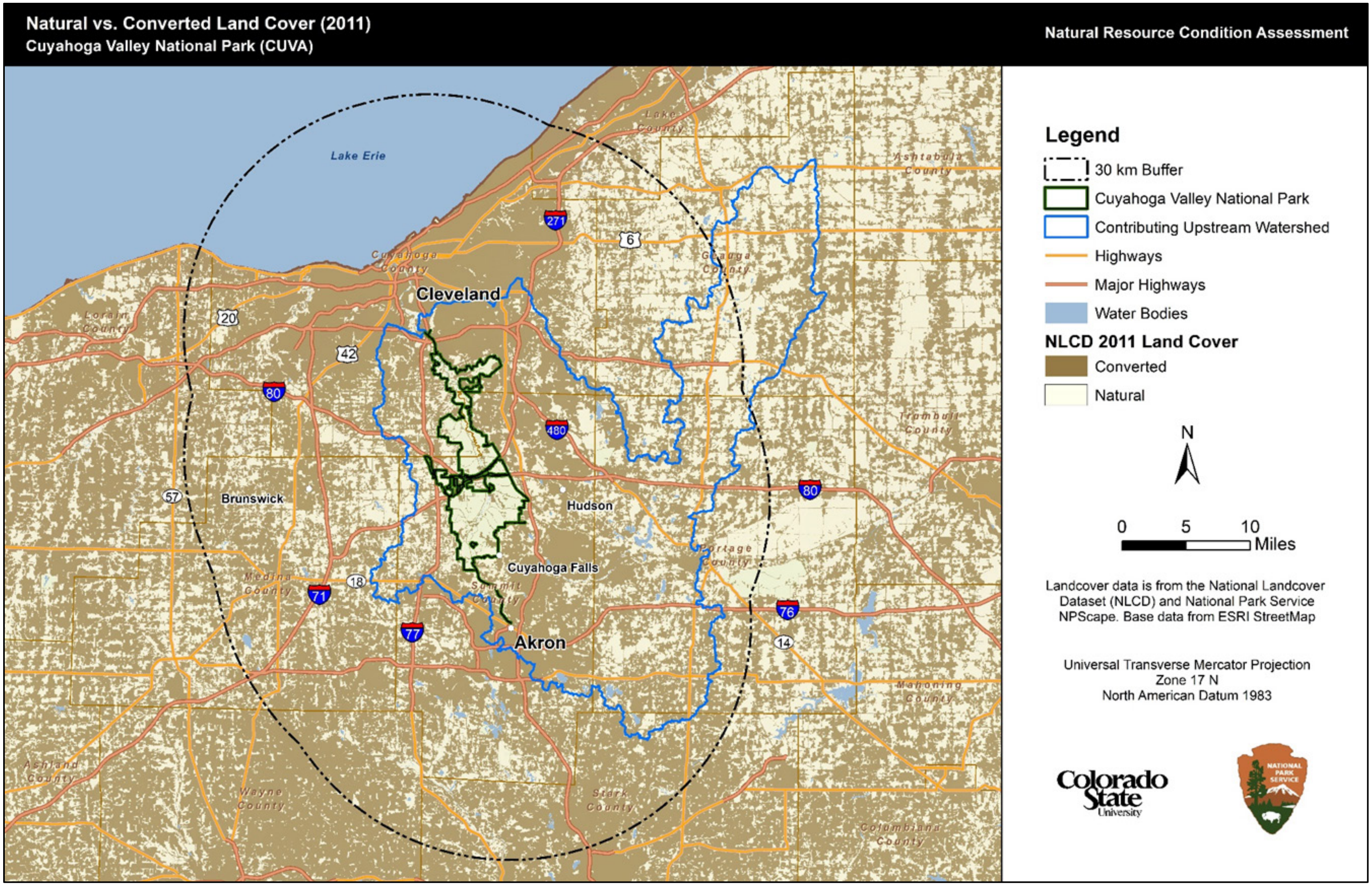


Figure 4.1-2. Natural vs. converted land cover classes within 3 km and 30 km of the park boundary, and within the contributing upstream watershed of the park (National Land Cover Dataset data provided by NPS NPScape Program; base data from ESRI Streetmap).

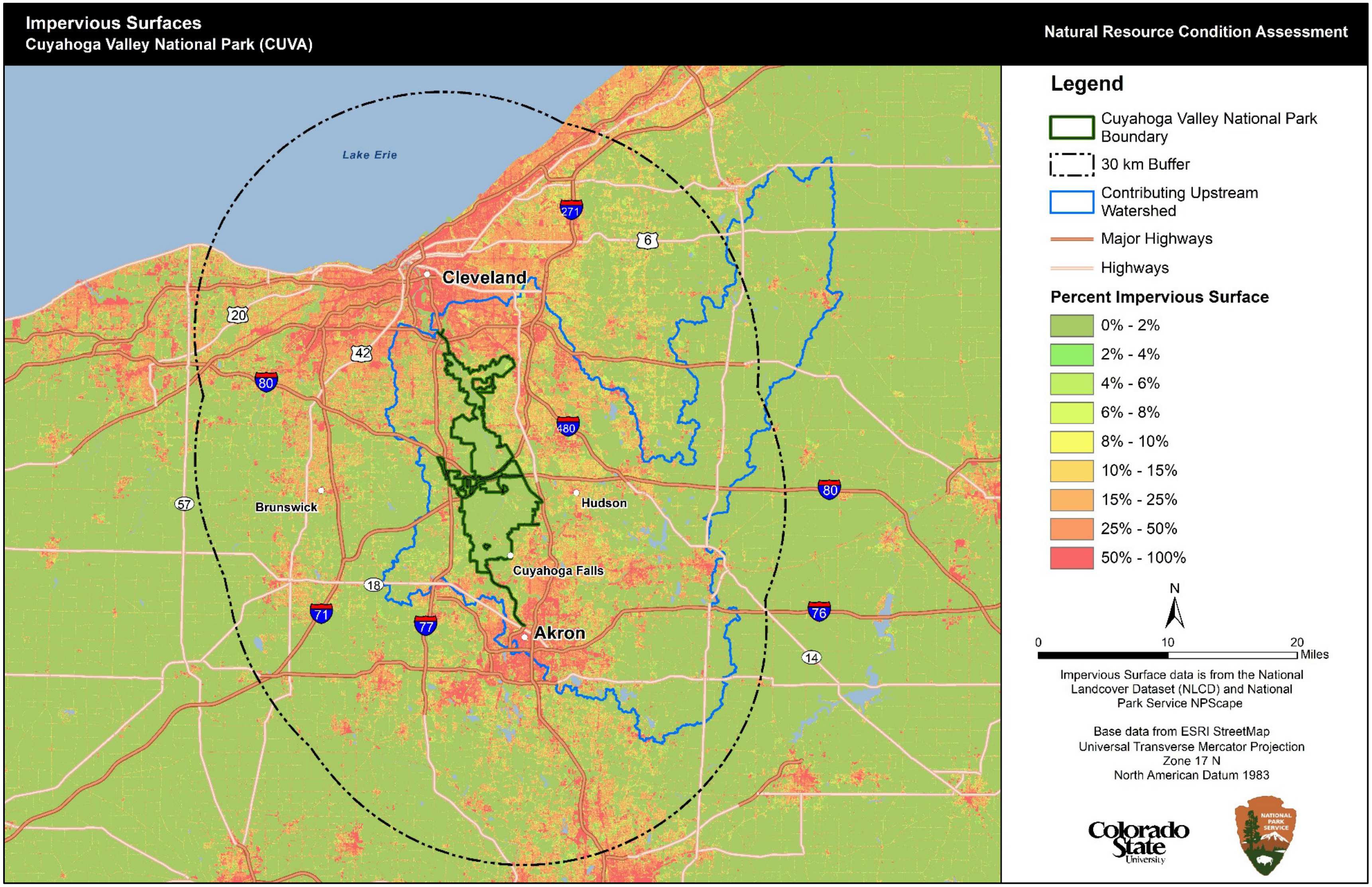


Figure 4.1-3. Percent impervious surfaces based on Anderson land cover classes within 3 km and 30 km of the park boundary, and within the contributing upstream watershed of the park (National Land Cover Dataset data provided by NPS NPScape Program; base data from ESRI Streetmap).

Table 4.1-5. Percent impervious surfaces acreage based on Anderson land cover classes within the contributing upstream watershed of the park (from National Land Cover Dataset data provided by NPS NPScape Program).

Percent Impervious Surface	Acres	% of Area
0%–2%	283,388	59.28%
2%–4%	11,767	2.46%
4%–6%	11,091	2.32%
6%–8%	10,115	2.12%
8%–10%	9,206	1.93%
10%–15%	19,946	4.17%
15%–25%	34,181	7.15%
25%–50%	59,441	12.43%
50%–100%	38,912	8.14%
Total	**478,046**	**–**

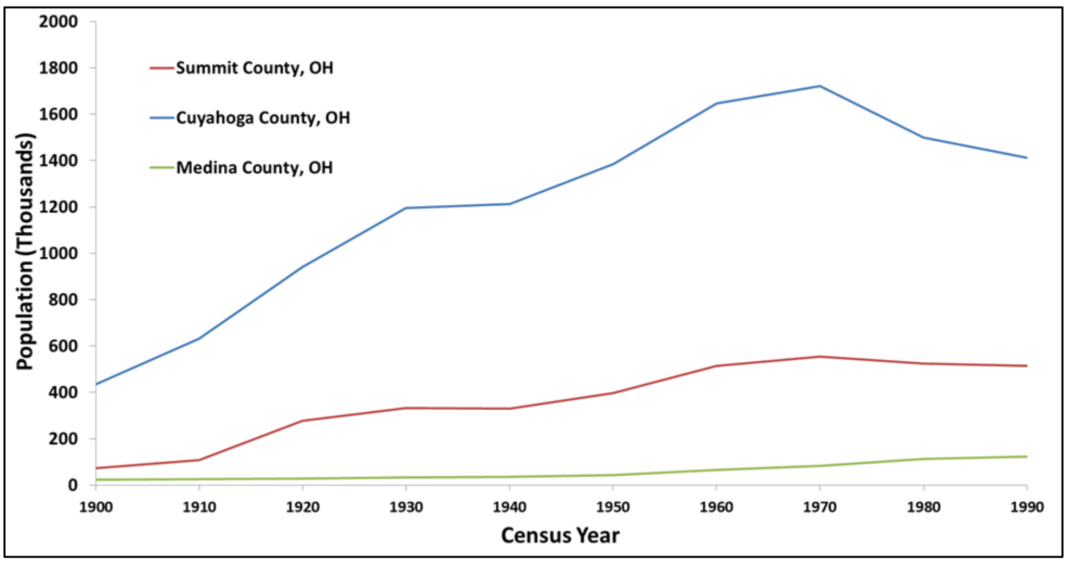


Figure 4.1-4. Historic population by decade for counties within 30 km of CUVA (U.S. Census Bureau 2018).

Population and Housing

Historic and Projected Population

High human population density has been shown to adversely affect the persistence of habitats and species (Kerr and Currie 1995, Woodroffe 2000, Parks and Harcourt 2002, Luck 2007). Conversion of natural landscapes to agriculture, suburban, and urban landscapes is generally permanent, and this loss of habitat is a primary cause of biodiversity declines (Wilcove et al. 1998). Human conversion of landscapes can alter ecosystems and reduce biodiversity by replacing habitat with non-habitable cover types and structures, fragmenting habitat, reducing availability of food and water, increase disturbance by people and their animals, alter vegetation communities, and increase light, noise, and pollution.

Historically, population has increased in the region, with a small decrease since the 1970s (Figure 4.1-4). Population density within 30 km of the park's boundary is moderate, with most of the area having a density of 21–750 people/km2 (Table 4.1-6, Figure 4.1-5). However, a significant amount of area (>16%) is composed of high density classes (751 to >3000 people/km2) associated with Cleveland and Akron. There is also a small amount of zero population density due to some census blocks being composed solely of industrial and retail areas within the more densely populated parts of Cleveland and Akron. There is a slightly increasing trend in population density. This increase is taking place in medium density classes, primarily the 76 to 750 people/km^2 categories, and appears to be due to reduced acreage with population densities of 21–71 people/km^2 in 1990.

Table 4.1-6. Population density classes and acreage for 1990, 2000, and 2010 by census block group for the park and surrounding 30 km buffer (U.S. Census Bureau block data provided by NPS NPScapeProgam).

	1990		2000		2010	
Population Density (#/km^2)	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**
0	1,964	0.16%	1,463	0.12	2,611	0.21%
1–20	10,131	0.81%	1,909	0.15%	730	0.06%
21–75	389,707	31.19%	337,508	27.01%	279,651	22.37%
76–150	285,862	22.88%	282,581	22.62%	300,182	24.02%
151–300	176,570	14.13%	180,138	14.42%	200,812	16.07%
301–750	178,066	14.25%	223,290	17.87%	227,608	18.21%
751–1200	70,006	5.60%	87,337	6.99%	106,858	8.55%
1201–1500	33,770	2.70%	34,096	2.73%	35,698	2.86%
1501–2000	25,914	2.07%	30,300	2.43%	33,608	2.69%
2001–3000	36,468	2.92%	36,321	2.91%	37,354	2.99%
>3000	40,986	3.28%	34,519	2.76%	24,779	1.98%

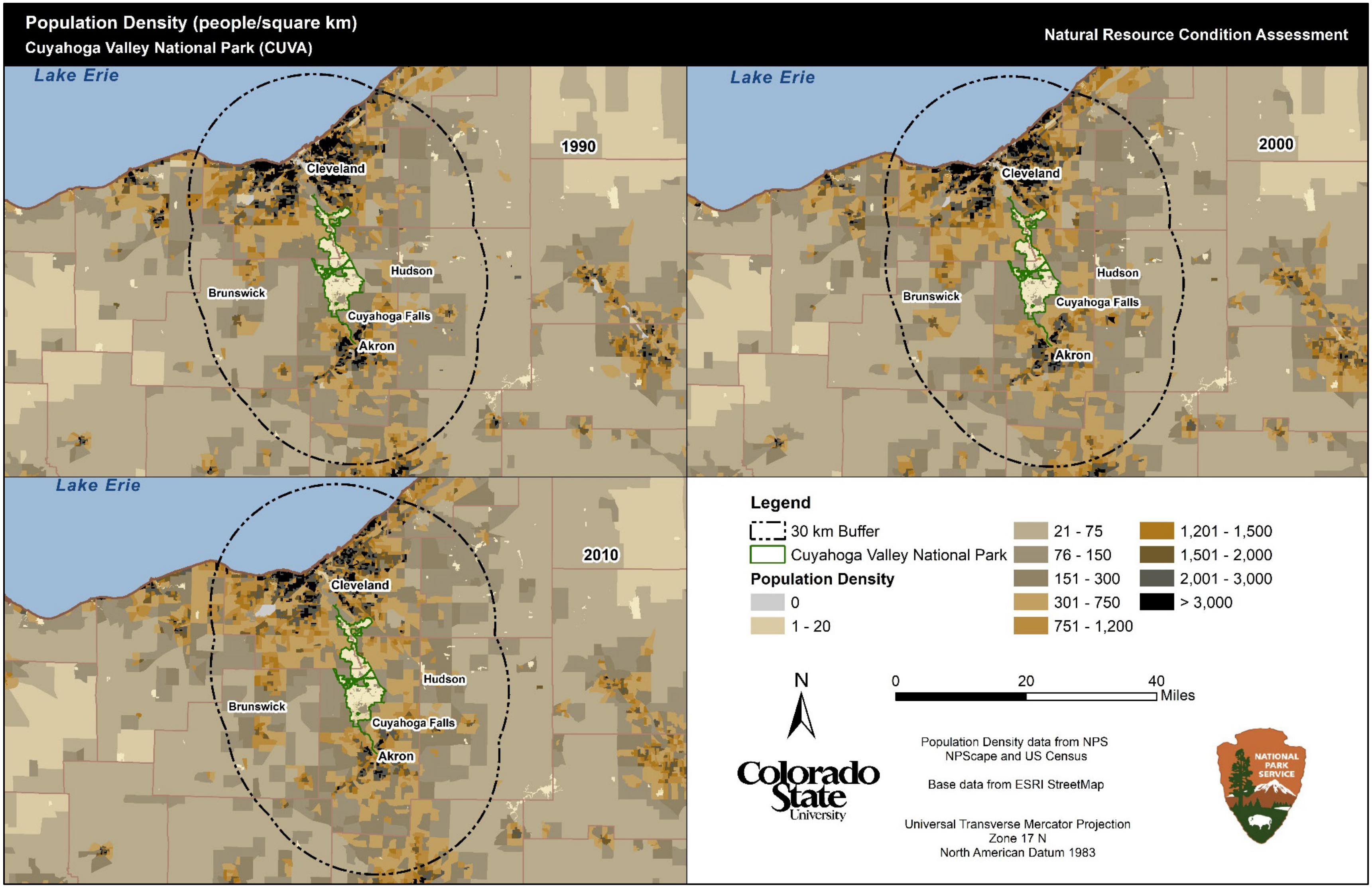


Figure 4.1-5. Population density for 1990, 2000, and 2010 by census block group for the park and surrounding 30 km buffer (U.S. Census Bureau data provided by NPS NPScape Program; base data from ESRI Streetmap).

Housing Density

Housing density in the region surrounding the park shows an increase in exurban and suburban development and corresponding decrease in rural development between 1970 and 2010 (Table 4.1-7, Figure 4.1-6). Similar trends for rural and suburban classes are projected through 2050. Areas shown in white in Figure 4.1-6 consist of city and state parks, Ohio National Guard, and NPS lands.

Table 4.1-7. Historic and projected housing density by decade for 1970–2050 for the park and surrounding 30 km buffer (SERGoM data provided by NPS NPScape Program).

Census Year	Rural (0–0.0618 units/ha)		Exurban (0.0618–1.47 units/ha)		Suburban (1.47–10.0 units/ha)	
	Acres	% of Area	Acres	% of Area	Acres	% of Area
1970	482,290	42.40%	372,007	32.70%	121,655	10.69%
1980	376,996	33.14%	442,170	38.87%	153,981	13.54%
1990	322,035	28.31%	475,250	41.78%	174,261	15.32%
2000	256,332	22.53%	520,833	45.79%	200,768	17.65%
2010	199,120	17.51%	572,414	50.32%	202,685	17.82%
2020	164,618	14.47%	596,845	52.47%	211,851	18.62%
2030	157,060	13.81%	593,462	52.17%	221,698	19.49%
2040	155,738	13.69%	586,558	51.57%	229,022	20.13%
2050	155,429	13.66%	579,572	50.95%	235,288	20.69%

Level of Protection

Most protected land area in the region is owned by federal and municipal entities (Table 4.1-8; Figure 4.1-7). The GAP status makeup is similar within each of the AOAs. Within 30 km of the Park and in the contributing upstream watershed, most protected land is in Status II or III, with a significant amount also in Status IV (Table 4.1-9). At least 84% of land area in each of the AOA's is not protected (or status unknown), which highlights the importance of CUVA and other parcels providing biodiversity protection in the region. Moreover, in protected areas such as CUVA natural processes and disturbance regimes are more likely to occur and support a greater degree of biodiversity, as well as provide critical linkages to the surrounding natural landscape.

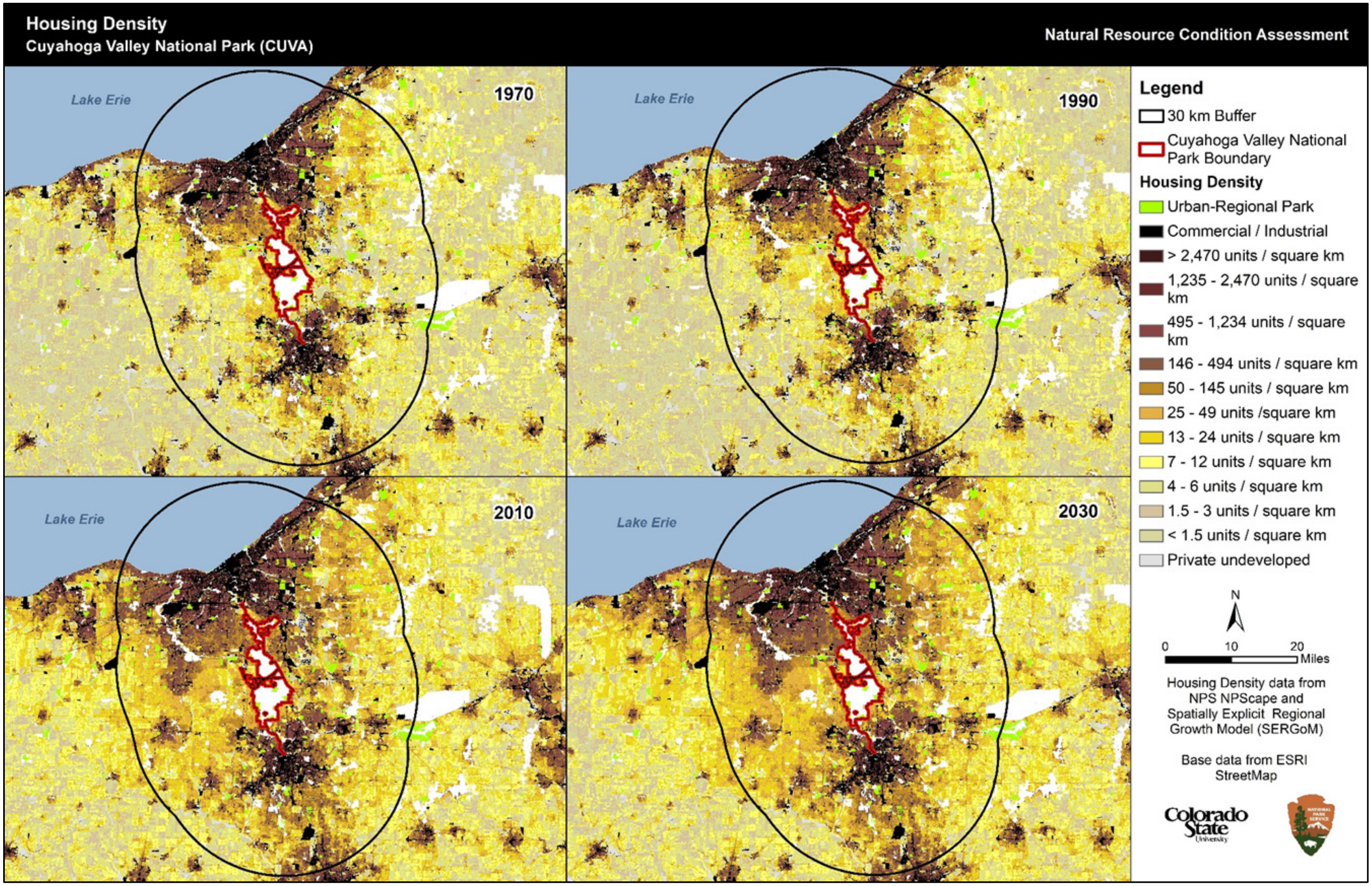


Figure 4.1-6. Historic and projected housing density for 1970, 1990, 2010 and 2030 for the park and surrounding 30 km buffer (SERGOM data provided by NPS NPScape Program; base data from ESRI Streetmap).

Table 4.1-8. Acreage of lands by ownership within 30 km of the boundary of CUVA, and within the contributing upstream watershed of the park (CBI 2013, NCED 2013). Percentages are the proportion of total AOA area.

	Park + 30 km Buffer		Contributing Upstream Watershed	
Ownership	**Acres**	**% of Area**	**Acres**	**% of Area**
Federal	24,022	1.72%	18,850	3.94%
Native American	0	0.00%	0	0.00%
State	10,802	0.77%	13,051	2.73%
City and County	37,574	2.70%	27,444	5.74%
Private Conservation	20,224	1.45%	12,435	2.60%
Joint Ownership/Unknown	12,772	0.92%	950	0.20%
Other Conservation Easement	379	0.03%	0	0.00%
Total	**105,773**	**7.59%**	**72,730**	**15.21%**

Table 4.1-9. Biodiversity protection status of lands within 30 km of the park boundary, and within the contributing upstream watershed of the park (CBI 2013, NCED 2013). Percentages are the proportion of total AOA area.

	Park + 30 km Buffer		Contributing Upstream Watershed	
Protection Level	**Acres[a]**	**% of Area[a]**	**Acres**	**% of Area**
I (highest)	2,640	0.19%	1,589	0.33%
II	29,524	2.12%	29,244	6.12%
III	47,619	3.42%	28,785	6.02%
IV (lowest/status unknown)	25,990	1.86%	13,112	2.74%
Total	**105,773**	**7.59%**	**72,730**	**15.21%**

[a] The remaining acreage within the area of analysis is comprised of private lands with no known conservation protection.

4.1.5. Land Cover and Land Use Summary

Overall, the park is within an exurban/suburban matrix landscape with a high proportion of developed land (Table 4.1-10). Most of the stressors to the landscape surrounding CUVA are related to the conversion of forest to housing developments, most of which is classed as exurban. This trend in land development, coupled with the lack of well-connected protected areas, should be of concern to the conservation of natural resources of Cuyahoga Valley National Park. This summary provides a useful context of known stressors, supports resource planning and management within the park, and provides a foundation for collaborative conservation with other landowners in the surrounding area.

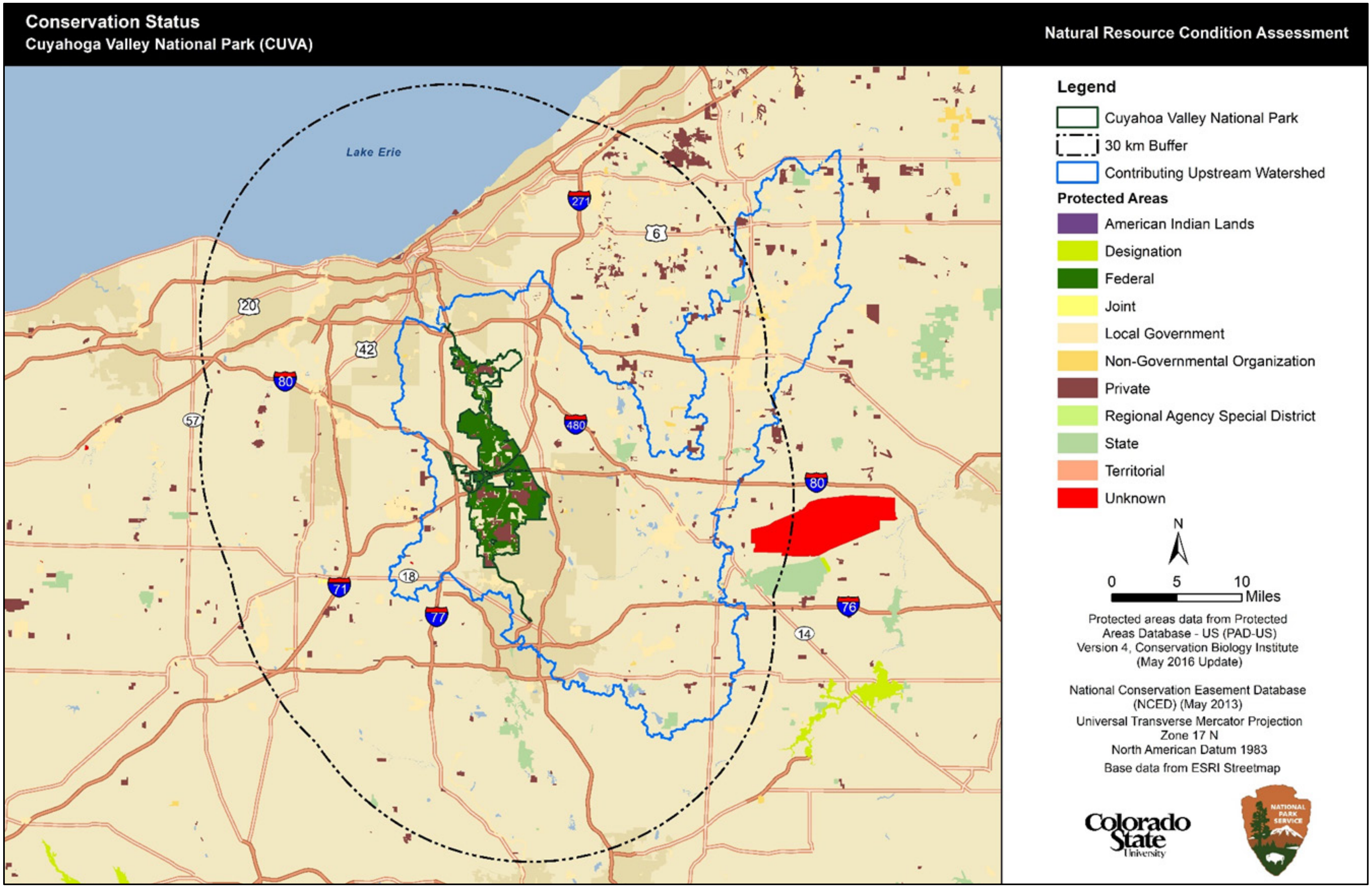


Figure 4.1-7. Conservation status of lands within 30 km of the CUVA boundary (CBI 2013, NCED 2013, base data from ESRI Streetmap).

Table 4.1-10. Summary for land cover and land use indicators, Cuyahoga Valley National Park.

Land Cover/Use Category	Indicator	Summary Notes Integrating Results for 3 km, Contributing Upstream Watershed and 30 km Areas of Interest
Land cover	Extent of Anderson Level II classes	Most of the acreage surrounding CUVA is deciduous forest, regardless of AOA. The next most prevalent land use is developed, open space followed by low intensity development.
	Extent of impervious surface area	There is a low degree of imperviousness in relation to areas in the region. This is due to the fact that most of the surrounding acreage is forest.
	Extent of natural vs. converted land cover	The proportion of converted acreage surrounding CUVA is moderate, but is low when compared to the surrounding region.
Population and Housing	Historic and projected population total and density	Population density within 30km of the park's boundary is moderate, with most of the area within this 30km radius having a density of 21–750 people/km^2. The population density of the area is attributable to the presence of the cities of Akron and Cleveland, OH within the AOA. Historically, county populations in the surrounding area have been increasing steadily with Cuyahoga County responsible for most of the increase.
	Housing density	Within a 30km radius of the park, the most notable trend is an increase in exurban and suburban areas and a corresponding decrease in rural acreage. Most of this change is in the area between Akron and Cleveland, OH.
Conservation Status	Protected area extent and biodiversity protection status	A small portion of the acreage in the region surrounding the park is protected through ownership or conservation easements. The rarity of protected lands within the region underscores the value of the park as a conservation island within a heavily urbanized region.

4.1.6. Uncertainty and Data Gaps

The primary source of uncertainty is associated with assumptions regarding the relationships between land ownership and conservation status. Although information about ownership and protection status can be useful, the degree to which biodiversity is represented within the existing network of protected areas is largely unknown (Pressey at al. 2002). Protection status and extent must be combined with assessments of conservation effectiveness (e.g., location, design, and progress toward conservation objectives) to achieve more meaningful results (Chape et al. 2005).

4.1.7. Sources of Expertise

- Bill Monahan, Ph.D., NPS Inventory and Monitoring Division, Fort Collins, Colorado. Dr. Monahan provided NPScape data summaries and consulted on the selection and use of various metrics.

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4.2. Night Skies

4.2.1. Background and Importance

National parks serve as refuges for the endangered resource of natural darkness and starry night skies. Existing studies from the NPS Midwest Region since 2000 found that dark night skies are rated as "extremely" or "very" important by 57% of visitor groups (Kulesza 2013). The National Park Service recognizes the significance of naturally dark night skies to humans and many wildlife species and aims to protect the night skies of parks just like other important natural resources. With nearly half of all species being nocturnal and requiring naturally dark habitat, the presence of excessive artificial light can cause significant impacts to these species (Rich and Longcore 2006). For humans, there is cultural, scientific, economic, and recreational value associated with high-quality night skies. *NPS Management Policies* state that the NPS "will preserve, to the greatest extent possible, the natural lightscapes of parks, which are natural resources and values that exist in the absence of human-caused light" (NPS 2006). The *Management Policies* also provide specific actions that the NPS will take to prevent the loss of dark conditions and natural night skies: restricting the use of artificial lighting where safety and resource requirements allow, utilizing minimal-impact lighting techniques, and providing shielding for artificial lighting (Peel 2000, NPS 2006).

The National Park Service defines a natural lightscape as the resources and values that exist in the absence of human-caused light at nighttime. Natural lightscapes are critical for nighttime scenery and nocturnal habitat. There are many species that depend on natural patterns of light and dark for navigation, predation and other natural processes. Light pollution is the introduction of artificial light either directly or indirectly into the natural environment. Light pollution can have a negative effect on the organisms within a park and can also reduce the enjoyment of park visitors; it degrades the view of the night sky by reducing the contrast between faint extraterrestrial objects and the background of the luminous atmosphere. An example of light pollution is sky glow, sometimes referred to as artificial sky glow, light domes, or fugitive light, which is the brightening of the night sky from human-caused light scattered into the atmosphere. Another form of light pollution is glare, which is the direct shining of light. Both of these forms of light pollution impact the human perception of nighttime, natural landscapes and features of the night sky (NPS 2015).

Excessive artificial light pollution in NPS units threatens to adversely impact natural and cultural resources and the quality of visitor experiences. It is important to document with reliable data existing baseline conditions of the lightscapes in national park units so that monitoring of long-term changes can be implemented and management actions taken to restore natural conditions, where necessary (NPS undated). Poor air quality in combination with light pollution can dim the stars and other celestial objects and lead to reduced ability to see starry skies. Poor air quality also "scatters" artificial light, resulting in parks near cities and other significant light sources having a greater "sky glow" than if pollution was not present (Kulesza 2013). The NPS has clearly declared its commitment to protecting night skies for the benefit of natural ecosystems and the enjoyment of current and future generations of park visitors.

Threats and Stressors

Light originating from modern development within and beyond the park's boundaries and from artificial lighting in the park threatens the natural and historic lightscape of the park and to the quality of visitor experiences. Sky glow from the greater urban areas of Akron and Cleveland significantly impacts the night skies at the park.

A comprehensive examination of landscape context related to land cover and land use, population and housing, all of which are correlated with light pollution, was performed for the area surrounding the park and is presented in the *Land Cover and Land Use* section within this chapter. Landscape context parameters can be highly correlated with ambient light levels. Therefore, changes in these factors can have significant impacts on the night sky of the park.

Indicators and Measures

- All-Sky Light Pollution Ratio (ALR)

4.2.2. Data and Methods

The NPS Natural Sounds and Night Skies Division (NSNSD) recommends ALR as a metric to assess the condition of the night skies at NPS units (Moore et al. 2013). The NSNSD characterizes park unit photic environment by measuring both anthropogenic and natural light. In contrast to nightscapes or natural night skies, photic environments are a broader concept that encompasses the totality of the pattern of light at night at all wavelengths. The ALR is a relatively coarse measure using the ratio of actual/current light to natural light. An ALR value of zero indicates natural light, while an ALR value of one indicates that light levels are 100% brighter than natural light from night skies (Moore et al. 2013). Researchers in collaboration with NPS developed U.S.-wide models that calculate estimated ALR values (Duriscoe et al. 2018). No park-specific night sky measurements or data have been recorded for CUVA.

4.2.3. Reference Conditions

The reference condition for the night sky in Cuyahoga Valley National Park is one in which the intrusion of artificial light into the night scene is minimal. Natural sources of light (such as moonlight, starlight, and the Milky Way) will be more visible from the park than anthropogenic sources. To help the park achieve its cultural mission, it is important that the night sky of the site retains its historic character.

Impact thresholds have been developed for non-urban (Level 1) and urban (Level 2) park night sky resources (Table 4.2-1) (Moore et al. 2013). Parks outside of designated urban areas are considered more sensitive to the impact of anthropogenic light and are assessed using lower thresholds of impact. Parks within urban areas, as designated by the U.S. Census Bureau, are considered less sensitive to the impact of anthropogenic light and are assessed using higher thresholds of impact. According to the U.S. Census Bureau (2010), CUVA is considered a non-urban park.

Table 4.2-1. Reference condition rating framework for ALR at Cuyahoga Valley National Park (Moore et al. 2013).

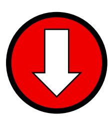
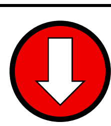
Indicator	Park Class	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Median All-Sky Light Pollution Ratio (ALR)	Non-Urban	ALR < 0.33	ALR = 0.33–2.0	ALR > 2.0
–	Urban	ALR < 2.0	ALR = 2.0–18.0	ALR > 18.0

4.2.4. Condition and Trend

Cuyahoga Valley National Park had a median ALR of 17.75, with values ranging from 10.2 to 41.0 (Figures 4.2-1, 4.2-2). This is considered a poor condition for non-urban parks, and nearly exceeds the poor threshold for urban parks. At these light levels the Milky Way may be visible when it is directly overhead; otherwise it is not apparent. The Andromeda Galaxy M31 may be barely visible. Little sense of naturalness remains in the night sky, and the landscape is clearly shadowed or illuminated. The horizon may appear to glow with anthropogenic light. Full dark adaptation by the viewer is not possible, and substantial glare may be present. Circadian rhythms may be disrupted.

Based on these results and the ongoing and projected trends in development and urbanization within the region and near the park (see Section 4.1), the condition of natural night skies at CUVA warrants significant concern with a deteriorating trend (Table 4.2-2). Confidence in the assessment is high.

Table 4.2-2. Condition and trend summary for natural night skies at Cuyahoga Valley National Park.

Indicator	Condition Status/Trend	Rationale
All-Sky Light Pollution Ratio (ALR)		All-sky light pollution ratio (ALR) is a measure of light pollution calculated as the ratio of median sky glow to average natural sky luminance. ALR for Cuyahoga Valley National Park is 17.75, which is considered a poor condition. Although no ALR trend data are available, the trend is inferred as deteriorating based on recent and anticipated increases in development and urbanization.
Night Skies overall		The condition of night skies warrants significant concern with a deteriorating trend. Confidence in the assessment is high.

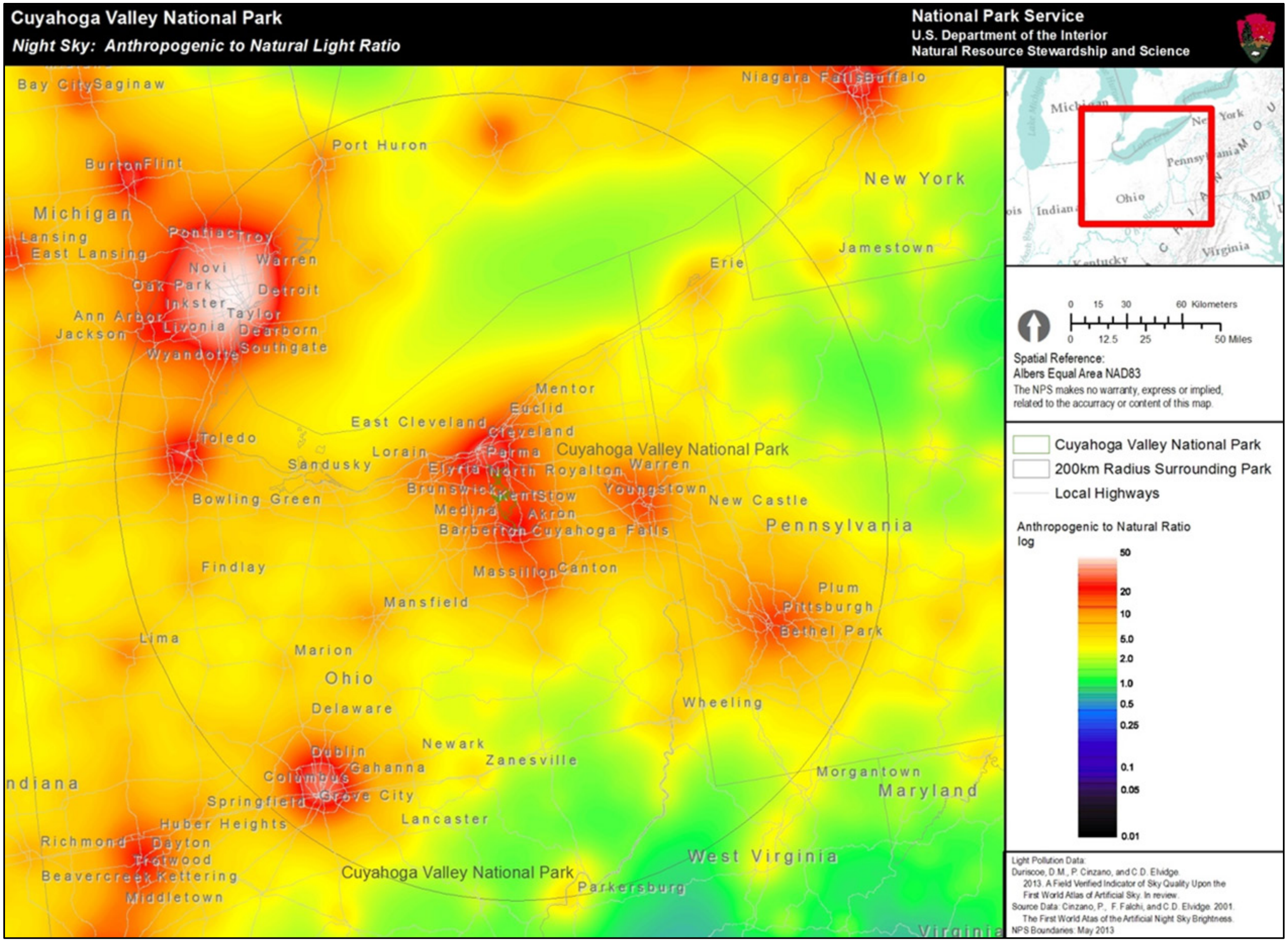


Figure 4.2-1. Regional view of regional all-sky light pollution ratio (ALR) values (graphic provided by NSNSD).

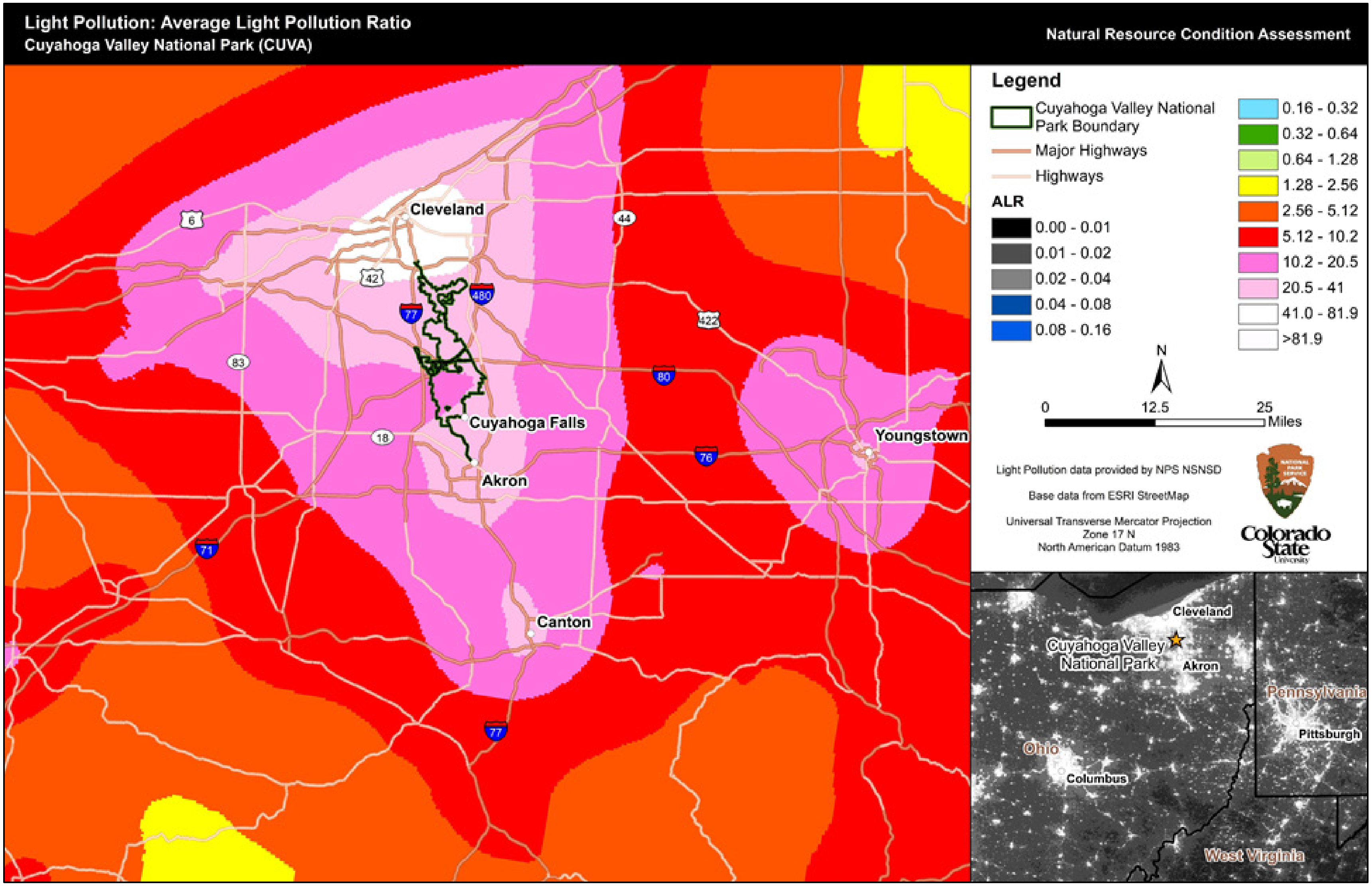


Figure 4.2-2. All-sky light pollution ratio (ALR) values in and around Cuyahoga Valley National Park (ALR data provided by NPS NSNSD; base data from ESRI Streetmap).

4.2.5. Uncertainty and Data Gaps

No on-site night sky monitoring studies have been conducted by the NPS in Cuyahoga Valley National Park. Additional measures for night skies could include horizontal illuminance, max vertical illuminance, Bortle Dark Sky Scale assessments, limiting magnitude estimation, and assessment of sky brightness using a charged couple device (CCD) and Unihedron Sky Quality Meter (SQM).

4.2.6. Sources of Expertise

- Jeremy White, NPS Natural Sounds and Night Skies Division
- Sharolyn Anderson, NPS Natural Sounds and Night Skies Division

4.2.7. Literature Cited

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4.3. Soundscape

4.3.1. Background and Importance

The acoustic environment includes all sounds present in the environment, and not just those audible to humans. All the natural sounds that occur within the boundaries of the National Park System units, the physical capacity for transmitting those natural sounds, and their interrelationships with other sounds comprise the natural acoustic environment of a park (NPS 2006). Visitors to national parks are often highly motivated to experience natural tranquility, sounds of nature, and solitude (McDonald et al. 1995, Krog et al. 2010, Mace et al. 2013). National Park Service management policies include directives related to soundscapes, including the affirmation that "The Service will preserve, to the greatest extent possible, the natural soundscapes of parks. The Service will restore to the natural condition wherever possible those park soundscapes that have become degraded by unnatural sounds (noise), and will protect the acoustic environment from unacceptable impacts" (NPS 2006). Excessive noise in NPS units threatens to adversely impact natural and cultural resources and the quality of visitor experiences. Cuyahoga Valley National Park has its own cultural soundscape that is both unique and appropriate to its particular place and period. Loud or inappropriate sound levels from sources such as aircraft, vehicles, and the modern era can detract from the visitor experience (NPS 2019). The NPS has clearly declared its commitment to protect intrinsic soundscapes for the enjoyment of current and future generations of park visitors.

Anthropogenic noise increasingly degrades, disturbs, and reduces visitor enjoyment (Mace et al. 2013, Rapoza et al. 2015, Weinzimmer et al. 2014). Most visitors prefer to hear sounds intrinsic to the natural and cultural settings of the park units they are visiting. Sounds are important because they can have a strong effect on people's perception and enjoyment of a landscape (Benfield et al. 2010). A growing body of research also documents the biological and behavioral impacts of unnatural and unusual noise on a variety of wildlife (Barber et al. 2009, Shannon et al. 2016). Many species depend on natural soundscape conditions—free from anthropogenic noise intrusions—to successfully reproduce and survive (Rabin et al. 2006, Habib et al. 2007, Shannon et al. 2016). In 2000 the NPS issued the *Director's Order #47: Soundscape Preservation and Noise Management* "to articulate National Park Service operational policies that will require, to the fullest extent practicable, the protection, maintenance, or restoration of the natural soundscape resource in a condition unimpaired by inappropriate or excessive noise sources" (NPS 2000). The order established guidelines for monitoring and planning to preserve park soundscapes.

The Cuyahoga Valley National Park (CUVA) *Foundation Document* (NPS 2013) identifies the importance of providing restorative experiences for the region's urban residents: "The park is valuable for discovery, exploration, and recreation that renews mind, body, and spirit in a rural setting often unavailable to urban residents" (NPS 2013). Despite the central importance of the park in providing visitors opportunities for restoration, the document notes that soundscapes and night skies in the park are impacted by surrounding development (NPS 2013). Moreover, the document lists soundscape assessments as a high priority.

The NPS Natural Sounds and Night Skies Division (NSNSD) has used acoustic modeling to estimate the anthropogenic impact to the ambient sound level at CUVA, which is the existing sound level minus the estimated natural sound level (Mennitt et al. 2013). Mean impact thus provides a measure of how much anthropogenic noise is increasing the existing sound level above the natural sound level, on average, in the park. For reference, for human visitors and resident wildlife, an increase in background sound level of 3 dB produces an approximate decrease in listening area of 50%. In other words, raising the sound level by 3 dB reduces the ability of listeners to hear the sounds around them by half. Furthermore, an increase of 7 dB leads to an approximate decrease in listening area of 80%, and an increase of 10 dB decreases listening area by approximately 90%.

Threats and Stressors

Primary threats to the natural soundscape include noise originating from modern transportation within and beyond the park's boundaries; from motorized park management activities; and from commercial, industrial, urban and exurban development. Traffic noise from numerous roads and highways is by far the largest source of noise (pers. comm. Chris Davis, November 2015). Aircraft noise is typically one of the most pervasive threats to natural sounds in NPS units, and is a notable source of anthropogenic noise at CUVA. Major nearby airports include Cleveland and Akron, Ohio, but many smaller airports also are located nearby. Commercial and private flights frequently fly above the valley (FlightAware 2018, Flightradar24 2018).Government reports indicate that air and vehicle traffic are projected to significantly increase at regional and national scales (U.S. Department of Transportation 2010a and 2010b, Ohio Department of Transportation 2018, FlightAware 2018).

A comprehensive examination of landscape context related to land cover/land use and population and housing, all of which can degrade natural and historic soundscapes, is presented in Section 4.1. These parameters can be highly correlated with ambient sound levels.

Indicators and Measures

- Anthropogenic sources of noise – presence/absence and relative noise level
- Traffic count volumes: I-271, I-80, US-82, Riverview Rd, Yellow Creek Rd
- Noise impacts (modeled) – median and maximum L_{A50} impact in dB

4.3.2. Data and Methods

The condition of the soundscape at CUVA was evaluated using input from park documents and staff, and results from nation-wide modeling of ambient sound levels (Mennitt et al. 2013, NPS 2015) provided by the NPS Natural Sounds and Night Skies Division (NSNSD). The sound map reports L_{A50} sound pressure level (in dB). This metric is a median sound level, meaning that sound levels are predicted to be greater than this level 50% of the time, and less than this level 50% of the time. The model predicts conditions during a typical summer day with calm weather conditions. Sound levels are often lower at night and during the winter (NPS 2018). The spatial resolution of the modeled sound is 270 m x 270 m. This analysis permitted estimation of the impact of anthropogenic noise on natural sound levels in the park. Observations and opinions from CUVA staff are also incorporated in this assessment with respect to desired soundscape conditions as well as sources of anthropogenic noise intrinsic and extrinsic to the park units.

A recent publication studied noise pollution in protected areas across the Continental United States (Buxton et al. 2017). Researchers used a metric termed "noise exceedance" to quantify the difference between the predicted A-weighted sound levels and predicted sound levels minimizing the influence of anthropogenic noise. In other words, it is the amount that anthropogenic noise raises sound above natural levels. Data generated for protected areas near CUVA were used to estimate exceedance levels for CUVA, which has similar land cover and land use characteristics as the study area.

<u>Decibel Scale</u>

Sound pressure levels are often represented in the logarithmic decibel (dB) scale. In this scale, 0 dB is equivalent to the lower threshold of human hearing at a frequency of 1 kHz. This scale can be adjusted to account for human sensitivity to different frequencies of sound, a correction known as A-weighting. Examples of common sound sources (both within and outside of park unit environments) and their approximate sound levels are shown in Table 4.3-1 (Lynch 2009).

Table 4.3-1. Sound pressure level examples from NPS and other settings (Lynch 2009).

Park Sound Sources	Common Sound Sources	Sound Level (dB*)
Volcano crater (Haleakala National Park)	Human breathing at 3m	10
Leaves rustling (Canyonlands National Park)	Whispering	20
Crickets at 5m (Zion National Park)	Residential area at night	40
Conversation at 5m (Whitman Mission National Historic Site)	Busy restaurant	60
Snowcoach at 30m (Yellowstone National Park)	Curbside of busy street	80
Thunder (Arches National Park)	Jackhammer at 2m	100
Military jet at 100m AGL (Yukon-Charley Rivers National Preserve)	Train horn at 1m	120

* dB re 20 µPa A-weighted broadband (12.5 Hz—20 kHz) sound level over varied measurement durations and at the distances indicated

4.3.3. Reference Conditions

The reference condition for the soundscape in CUVA is one dominated by natural and cultural sounds that are intrinsic to the park. Natural sounds for the reference condition include birds, wind, rain, running water, and insects, while the historic soundscape included sounds from the Valley Railway, Ohio & Eerie Canal, small farms, and historic communities. A condition rating system for the soundscape indicators incorporating guidance from NSNSD and the authors is presented in Table 4.3-2.

Table 4.3-2. Reference condition rating framework for soundscape indicators at CUVA.

Indicator	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Anthropogenic Sources of Noise	Infrequent, low, or inaudible levels of anthropogenic noise. Annoyance level of visitors low. Recognizable natural sounds, bird chorus, mammal vocalizations, river current, wind, etc.	Moderately frequent and audible anthropogenic noise. Annoyance level of visitors moderate.	Frequent and highly audible anthropogenic noise. Annoyance level of visitors high.
Road Traffic Volume	Traffic levels and proportion of commercial trucks in I-275, I-80, US-82, and Riverview Rd, Yellow Creek Rd and other roads not exceeding levels of 2015.	1–5% increase in total traffic volume from 2015. Similar increase in proportion of heavy commercial trucks.	>5% increase in total traffic volume from 2015. Increase in proportion of heavy commercial trucks.
Anthropogenic L_{A50} Sound Level Impacts	Median impact ≤ 3 dB Maximum impact ≤ 7.5 dB	3 dB < Median impact < 5 dB 7.5 dB < Maximum impact < 10 dB	Median impact ≥ 5 dB Maximum impact ≥ 10 dB

4.3.4. Condition and Trend

Anthropogenic Sources of Noise

The following common sources of anthropogenic noise were identified by staff members at CUVA (pers. comm. Lisa Petit, November 8, 2015): vehicle traffic from many nearby roads and highways (especially motorcycles), scenic railway, corn cannons and other auditory methods utilized by local farmers to control nuisance wildlife. Most of anthropogenic noise sources originate on non-NPS lands within the boundary or from outside the park. The condition of this indicator warrants significant concern, with a deteriorating trend and a high level of confidence.

Traffic Volumes

We examined annual traffic volumes available for main roads and highways in and near the park. According to the Ohio Department of Transportation, the Average Daily Traffic and Commercial Vehicles Interactive Map, I-80 has the highest flow of traffic of any road at CUVA, with an annual average daily traffic volume of 47,174, of which 11,752 are trucks. Table 4.3-3 summarizes annual average daily traffic volume for some roads at the park. The change in total and truck traffic between 2015 and 2017 for most roads averaged over +5% (Ohio Department of Transportation 2018). Based on this data, the indicator warrants moderate concern with a deteriorating trend and a medium level of confidence.

Table 4.3-3. Annual average daily traffic volume and heavy commercial trucks for roads crossing Cuyahoga Valley National Park, OH (Ohio Department of Transportation 2018).

Road Segment	Vehicle Type	Annual Average Daily Traffic						
		1992	1994	2008	2009	2015	2017	% Change 2015 to 2017
I-80 (between I-271 and Riverview Rd)	Cars Trucks	–	34,180 11,674	–	–	44,826 11,167	47,174 11,752	5.2 5.2
I-271 (between I-77 and I-80	Cars Trucks	21,930 4,100	–	–	–	31,248 4,968	32,638 5,189	4.5 4.4
US-82 (between Riverview Rd and Chaffee Rd)	Cars Trucks	14,540 460	–	–	–	10,523 467	11,365 564	8.0 20.8
Yellow Creek Rd (between Sand Run Rd and W Bath Rd)	Cars	–	–	6,650	–	6,672	7,202	7.9
Riverview Rd. (between Everett Rd and Bolanz Rd)	Cars	–	–	–	5,680	5,301	5,673	7.0

Anthropogenic Impacts on Ambient Sound Level (Modeled)

In CUVA, the median modeled L_{A50} sound level impact was 7.8 dB and the maximum impact value was 13.7 dB. Modeled mean impacts in the area immediately surrounding CUVA are shown in Figure 4.3-1. Based on these modeled sound level impact results, CUVA median anthropogenic sound impacts exceed 5.0 dB and maximum sound impact levels exceeding 10 dB.

The area within the park with the lowest anthropogenic sound level impacts is the central area of the park furthest from the city centers of Cleveland and Akron. The areas with the highest impacts are the northern and southern ends of parks nearest Cleveland and Akron

Noise exceedance levels calculated by Buxton et al. (2017) indicate noise exceedance levels are more than 10 dB in most of the park and closer to 32 dB for portions of it (Fig 4.3-2). Noise exceedance levels inside most of the park were lower than areas around the park, indicating possibly a better-preserved soundscape within the park. The condition of the modeled sound indicator warrants significant concern with a medium confidence level given the lack of an on-site acoustic assessment. No trend data are available.

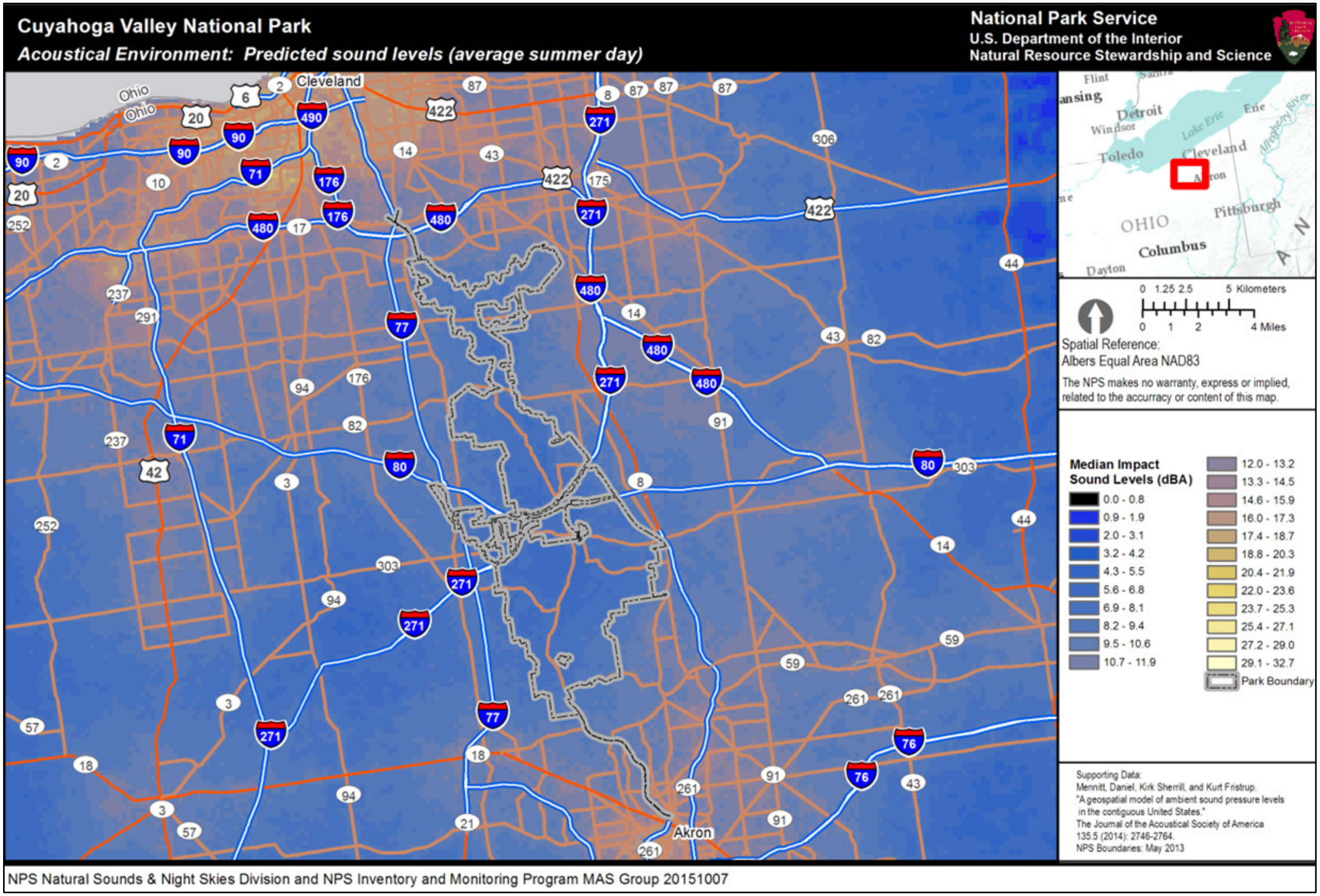


Figure 4.3-1. Modeled mean sound level impacts in the area immediately surrounding CUVA. Graphic provided by NSNSD (NPS 2015).

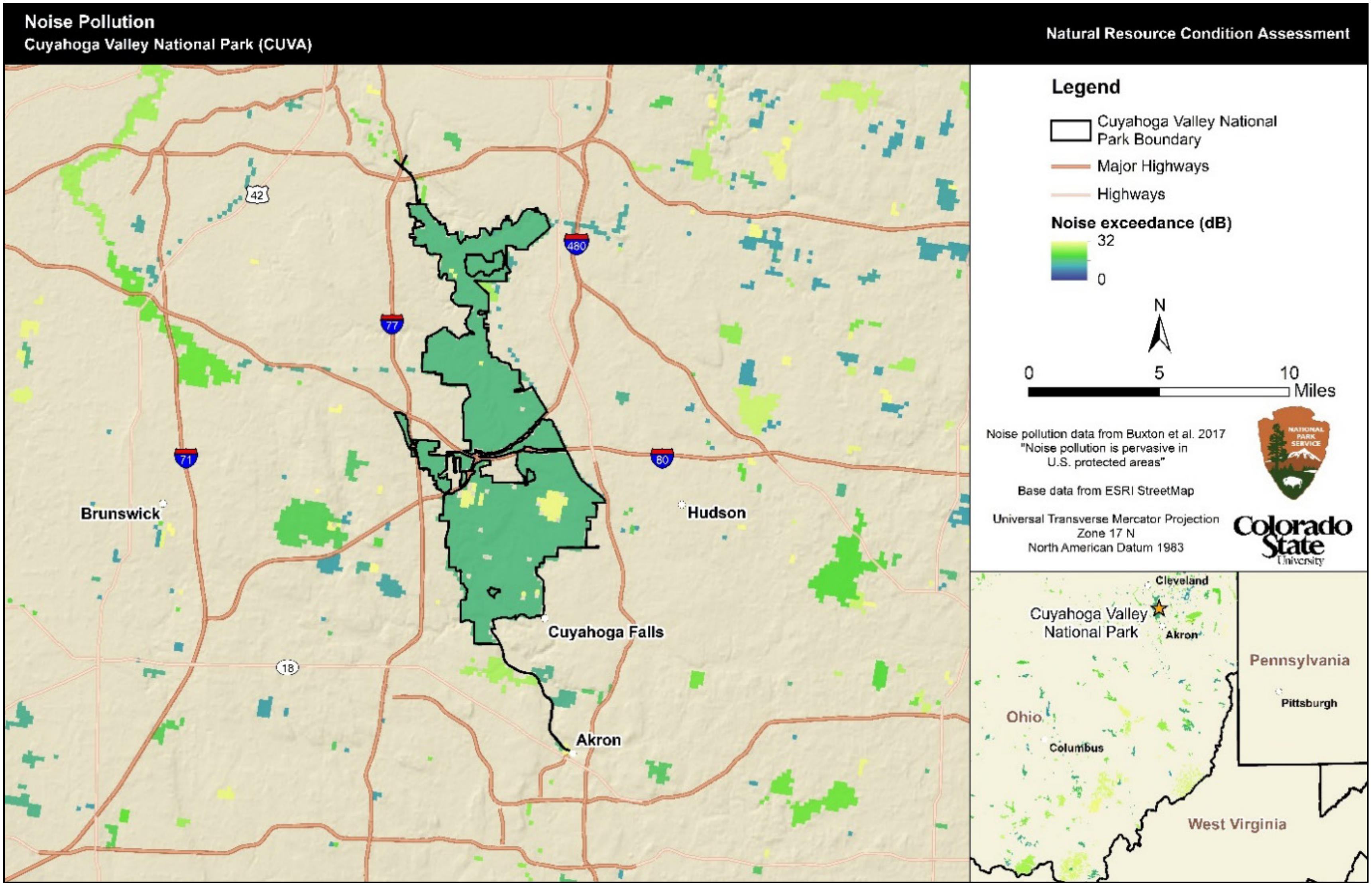
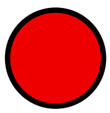
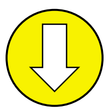
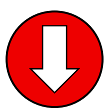
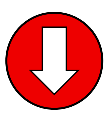


Figure 4.3-2. Modeled noise exceedance level inside CUVA and on other protected lands surrounding CUVA. Green to yellow colors indicate higher levels of anthropogenic noise. Exceedance levels are lower inside the park compared to some of the surrounding protected lands (Buxton et al. 2017). Base data from ESRI Streetmap. No data are available for private lands.

Overall Condition

Results indicate that the condition of the soundscape at CUVA warrants significant concern, with a deteriorating trend due to projections for increased road and air traffic and population growth over time (Table 4.3-4). Nationwide modeling of anthropogenic sound level impacts indicates that modern noise intrusions are substantially increasing the existing ambient sound level above the natural ambient sound level of the park (median impact = 7.8 dB). As long as noise from the adjacent roads and development remains pervasive in the park, the condition of the soundscape will likely continue to deteriorate. The confidence associated with these ratings is medium due to the limited availability of quantitative data collected on site.

Table 4.3-4. Condition and trend summary for the soundscape at Cuyahoga Valley National Park.

Indicator	Condition Status/Trend	Rationale
Anthropogenic Sources of Noise		Noise from anthropogenic sources is pervasive. Noise from modern transportation on adjacent roads and highways, as well as from nearby farms, particularly threaten the park's natural soundscape.
Traffic volumes		There seems to be a slight trend towards an increase in traffic levels in some of the roads that cross CUVA (Table 4.3-3). Average traffic volumes on primary roads crossing the park increased over 5% from 2015 to 2017. If this trend continues, the natural soundscape will be further impacted.
Modeled L_{A50} Sound Level Impacts		Anthropogenic noise is significantly increasing the existing ambient sound level above the natural ambient sound level of the park (median impact > 5.0 dB, maximum impact > 10.0 dB). Ground and air traffic are generally projected to increase over time.
Soundscape overall		Condition warrants significant concern with a deteriorating trend. Confidence in the assessment is medium.

4.3.5. Uncertainty and Data Gaps

Neither acoustical monitoring studies to measure ambient sound levels and audibility of different intrinsic and extrinsic sound sources nor evaluative research to determine the social impacts of existing soundscape conditions on visitor experiences have been collected on-site in CUVA.

4.3.6. Sources of Expertise

- Emma Lynch, Acoustical Resource Specialist, NPS Night Skies and Natural Sounds Division
- Lisa Petit, Chief of Resource Management, Cuyahoga Valley National Park

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4.4. Climate Change

4.4.1. Background and Importance

Climate change is increasingly recognized as a major stressor of biological taxa, communities and ecological systems. Understanding the magnitude and effects of changing climate is essential within the NPS to "manage for change while confronting uncertainty" while developing new management and adaptation strategies (National Park System Advisory Board Science Committee 2012) and a significant scientific component of the NPS *Climate Change Response Strategy* (NPS 2010).

An NPS Climate Change Resource Brief (NPS 2014) based upon research from Monahan and Fisichelli (2014) shows that the local climate in the vicinity of CUVA is already getting hotter and wetter. Climate change may also affect visitation patterns at CUVA (NPS 2015b). An overall increase in visitation (2–4% annually) as well as an increase in shoulder season visitation (7–14%, shoulder season is defined as two months prior and two months following peak season) may require park management to alter planning schedules (NPS 2015b).

Overall climate change vulnerability for a particular resource is estimated using a combination of exposure, sensitivity and adaptive capacity (Glick et al. 2011). The synopsis of potential changes to the park's climate presented here characterizes the "exposure" component of resource vulnerability. Climate change is examined here using modeled future climate scenarios, but potential resource vulnerability and management implications are based on the relative amounts and directions of changes rather than specific magnitudes or thresholds of change. Although the park can do its part to mitigate greenhouse gas emissions and optimize the efficiency of park operations vis a vis greenhouse gases, climate change and its associated effects on park resources are largely out of the control of park managers. The impacts of climate change are already being observed and will require an evaluation of the vulnerability of park resources. Moreover, specific and diverse adaptation measures for some park resources may be necessary to mitigate effects of climate change and transition to future climatic conditions.

<u>Threats and Stressors</u>

Increases in atmospheric greenhouse gases are resulting in changes in global, regional and local climates. Changes in the amounts and patterns of temperature and precipitation have numerous direct and indirect effects on environmental conditions and biota. An increase in the frequency of extreme weather is also anticipated under climate change.

<u>Indicators and Measures</u>

- Temperature changes from baseline – minimum, mean, and maximum temperatures (monthly)
- Precipitation changes from baseline – annual and seasonal; very heavy events
- Palmer Drought Severity Index (PSDI) – historic period of record
- Observed and projected changes in frost-free period

4.4.2. Data and Methods

A variety of data and analysis approaches are used to characterize the climate during the historic period of record and examine possible changes in climate for the park. A combination of site-specific and regional results is presented. Historic climate and modeled future climate change were examined for the area extending approximately 30 km from the park boundary. Because the park is relatively small and has relatively little elevation change within its boundaries, climatic variation within the park is minimal; monthly values were therefore averaged across the area of interest.

Consolidation of future modeled climates and comparisons with historic baseline and graphic representation of results was supported by the USGS North Central Climate Science Center (NCCSC) hosted by Colorado State University. Future climate projections for the NCCSC products are presented for several scenarios of future greenhouse gas concentrations (i.e., emission scenarios); representative concentration pathway (RCP) 8.5 represents the high emissions scenario and RCP 4.5 represents a moderate emissions scenario. Comparing carbon dioxide concentrations and global temperature change between the 2000 Special Report on Emission Scenarios (SRES) and the 2010 Representative Concentration Pathways (RCP) scenarios, SRES A1 is similar to RCP 8.5, SRES A1B is similar to RCP 6.0 and SRES B1 is similar to RCP 4.5 (Walsh et al. 2014a). Examination of historic climate data used PRISM (4 km) data downloaded from https://cida.usgs.gov/ (PRISM Climate Group 2014). Climate projections for non-spatial graphics use CMIP5 downscaled data downloaded from the Green Data Oasis website (http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html) (CMIP5 Modeling Groups 2014). CMIP5 downscaling procedures are described in Maurer et al. (2002). Approximately 35 general circulation models (GCMs) that use quantitative methods to simulate the interactions of the atmosphere, oceans, land surface, and ice were used for the NCCSC summaries. Because the variability in results among models makes interpreting results problematic, ensemble summaries were used to combine the simulations of multiple GCMs and quantify the range of possibilities for future climates under the different emission scenarios. Using ensemble median values based on the results from many GCMs provides a more robust climate simulation versus using results of individual models (Girvetz et al. 2009). Seasonal summaries use the following groupings: winter = December, January, and February; spring = March, April, and May; summer = June, July, and August; and autumn = September, October, and November.

The Palmer Drought Severity Index (PDSI) uses temperature and precipitation data to calculate water supply and demand, incorporates soil moisture, and is considered most effective for unirrigated cropland (Palmer 1965, USDA 2014). Long-term drought is cumulative, so the intensity of drought during a point in time is dependent on the current weather patterns plus the cumulative patterns of the previous period. The Index is used widely by the U.S. Department of Agriculture and other agencies. PSDI values range between −4.00 or less (extreme drought) and +4.00 or greater (extreme moisture). The index uses a value of 0 as "normal". The Palmer Index is most effective in determining long term drought (i.e., lasting at least several months). Monthly PSDI values were obtained from the National Climatic Data Center (NCDC 2018). Assumptions of the PSDI regarding the relationship between temperature and evaporation may give biased (i.e., overestimated evaporation) results in the context of climate change (Sheffield et al. 2012). However, examination of historic PSDI does appear to corroborate known drought periods and the PSDI approach is not used to model future drought.

The length of the frost-free period, which corresponds with the area's growing season, is an important determinant in which plants will grow and flourish in a particular region (Walsh 2014b). These observed climate changes are correlated with increases in satellite-derived estimates of the length of the growing season (Jeong et al. 2011). The frost-free season length, defined as the period between the last occurrence of 32°F in the spring and the first occurrence of 32°F in the fall, has been gradually increasing since the 1980s (USEPA 2012). The length of the frost-free period can alter plant phenology. Increases in temperature are responsible for plants flowering earlier in the spring and the delayed onset of dormancy in autumn. This affects not only synchrony among plants, pollinators and complex evolutionary adaptation, but can shorten (or lengthen) a plant's growing season. Phenology also plays an important role in the amount of water released to the atmosphere via evapotranspiration, sequestration of carbon in new growth, and the amount of nitrogen utilized from the soil (Ibanez et al. 2010).

4.4.3. Reference Conditions

For most indices, the reference condition for this assessment is an 85-year period from about 1895, when meteorological data was first collected, to 1980, when a significant change in many climate indices roughly began. Although there may be some changes occurring during this period, the long reference period avoids bias associated with wet, dry, warm and cold periods or extreme events such as prolonged or severe drought. Some analyses of historic data use a 1950–1980 baseline because of limited dates associated with downscaled CMIP5 data. For frost-free season length, the baseline period was 1901–1960.

4.4.4. Historic Conditions, Range of Variability and Modeled Changes

<u>Temperature</u>

Historic Trends

A linear model was fit to average minimum and average maximum monthly temperature for 1895–1980 and 1980–2012 in the vicinity of CUVA (Figure 4.4-1). The earlier period corresponds to a timeframe that is generally associated with no change in climate or a slower rate of change compared to 1980 or later. At CUVA, mean minimum monthly temperatures did not increase significantly over time during 1895–1980 ($p=0.37$) or from 1980–2012 ($p=0.27$). The model results for mean monthly maximum temperature over time were not statistically significant for either period (p values of 0.08 and 0.32, respectively).

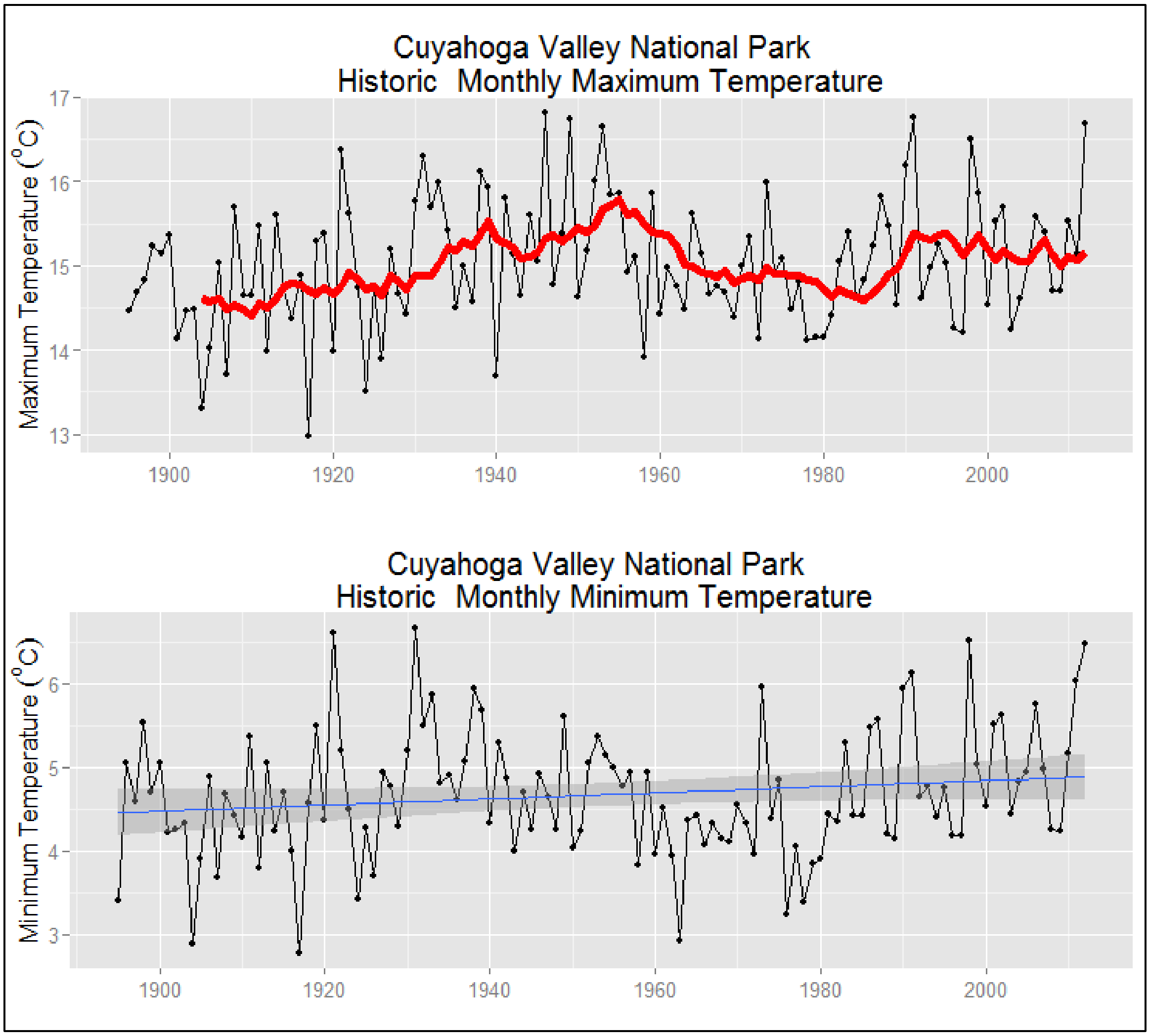

Figure 4.4-1. Historic PRISM data for maximum temperature showing significant linear model fit (top) and minimum temperature with a five year lag running mean (bottom). (Data and graphic prepared by NCCSC).

Trends in monthly maximum temperatures over time are further illustrated in a graphical representation of the data for the period of record (Figure 4.4-2, top), which normalizes differences between a baseline period of 1895 to 1980 with individual monthly values. For example, relative to the baseline period, cooler temperatures across most months are evident in the period before 1980 compared to more recent years. High temperatures associated with severe droughts that occurred in the 1930s, 1950s, and 2010s are clearly shown in Figure 4.4-2 (top). An anomaly plot showing annual mean temperatures over time further illustrates significant changes in this variable during the recent past, with minimum temperatures for most years since 1980 being 0.5–2.0 deg. C above the long term average (Figure 4.4-3). Monthly data was also grouped by season into model quartiles for minimum temperature (Figure 4.4-4). Seasonal data shows a possible increase in minimum temperatures in spring and summer over the past several decades.

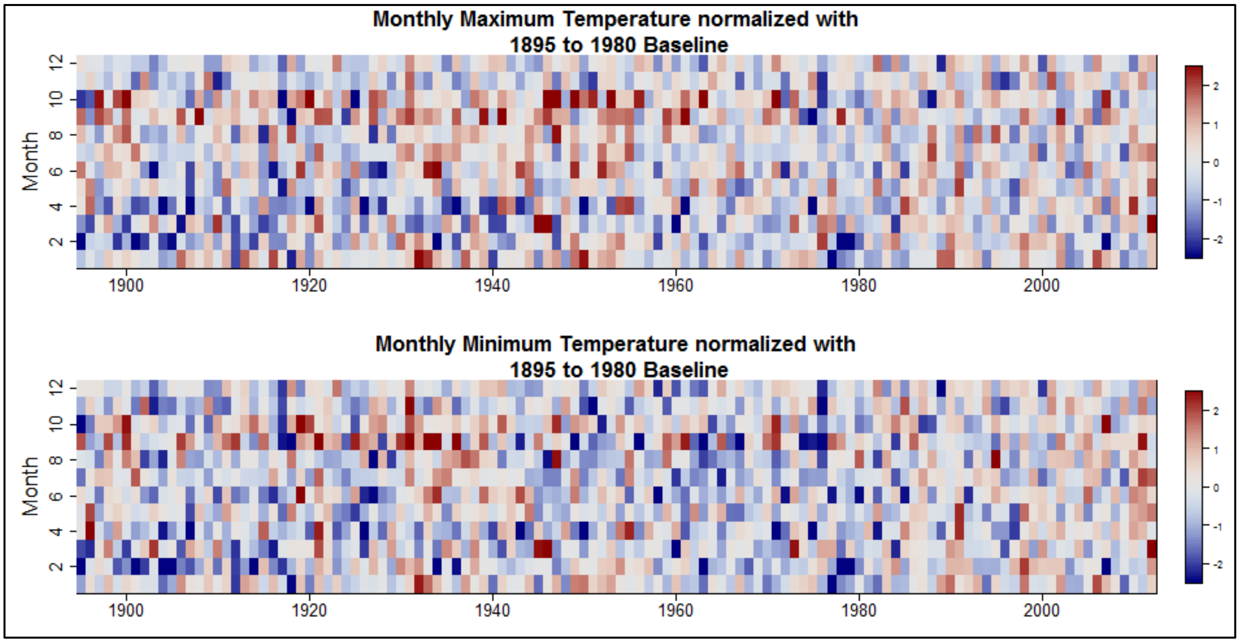

Figure 4.4-2. Mean monthly minimum temperature (top) and monthly maximum temperature (bottom) showing the normalized difference from a baseline (1895–1980) period for each month and year for Cuyahoga Valley National Park. The baseline is calculated monthly within the specified year range. The pixels are normalized by month and colors range from +/− 2.5 standard deviations from the mean of the baseline period. Red cells are warmer than baseline, while blue cells are cooler than baseline. (Data and graphic prepared by NCCSC).

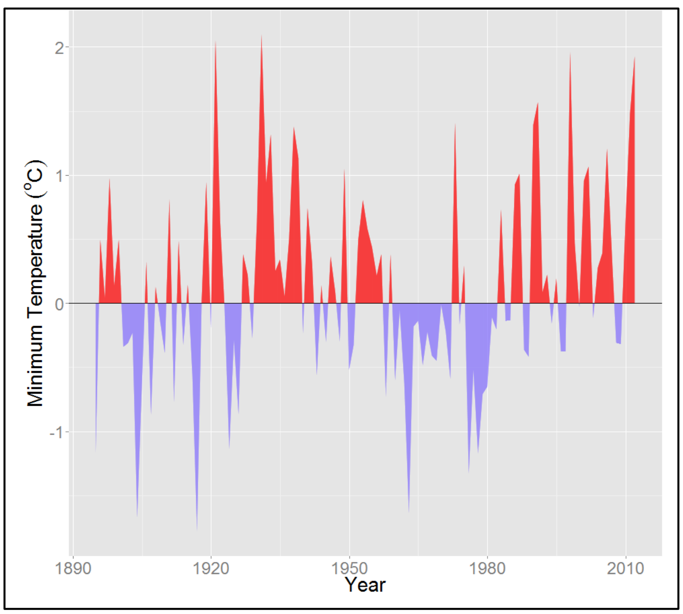

Figure 4.4-3. Anomaly plot for mean minimum temperature showing the difference between individual years from 1895 to 2012 and a baseline (1895 to 1980 average) for Cuyahoga Valley National Park. (Data and graphic prepared by NCCSC).

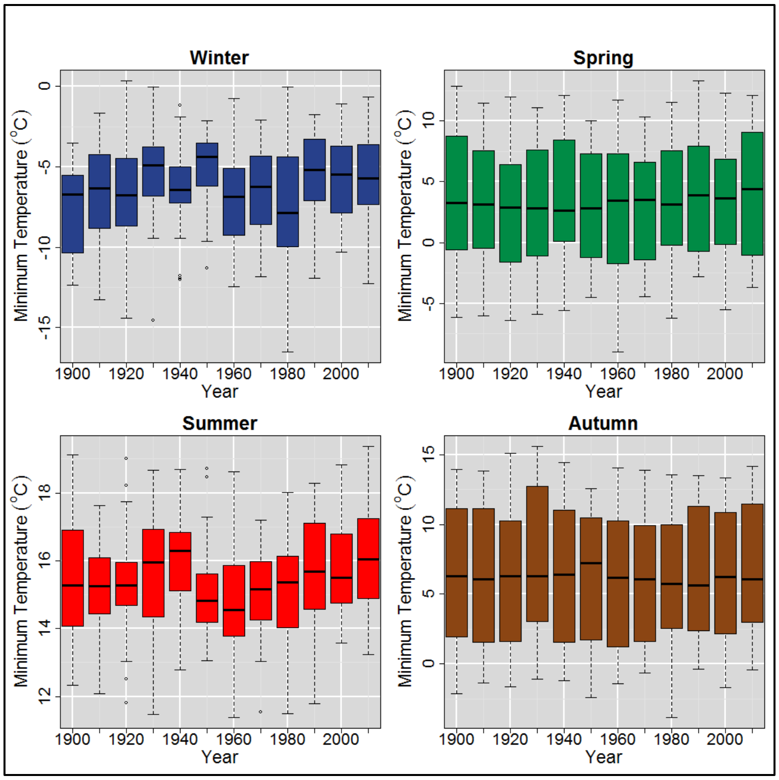

Figure 4.4-4. Seasonal historic mean minimum temperature quartiles using PRISM data at Cuyahoga Valley National Park (Data and graphic prepared by NCCSC).

Modeled Future Changes

Models indicate that temperatures at the park will rise significantly under climate change (Figure 4.4-5). According to median ensemble estimates, both minimum and maximum temperature are expected to increase by approximately 1.5–2.0 °C by 2050, and by approximately 2.0–6.5 °C by 2100, depending on the scenario (Figure 4.4-5).

Precipitation

Historic Trends

Historic trends in monthly and annual precipitation for 1895–2010 were examined to understand patterns and variability. Mean monthly precipitation appears to be increasing for some months in the latter half of the period of record, but patterns of seasonality are not clear (Figure 4.4-6). Linear regression of mean monthly precipitation with time were significant for the 1895–1980 period ($p=0.022$) but were not significant for the 1980–2012 period ($p=0.297$) (Figure 4.4-7). Variability in seasonal and annual precipitation is relatively high.

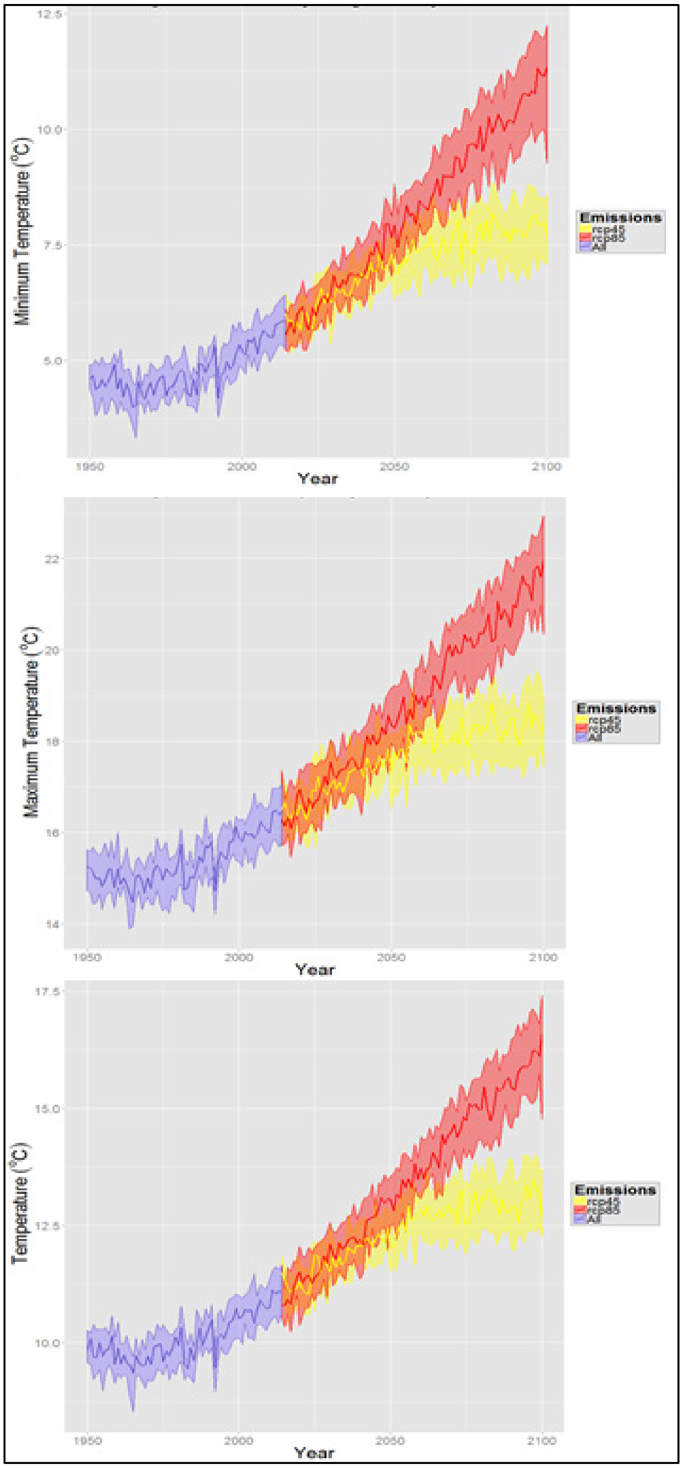

Figure 4.4-5. Projections for annual minimum, maximum and mean temperature with median, 25 and 75% quantiles grouped by emissions scenario for Cuyahoga Valley National Park. (Data and graphic prepared by NCCSC).

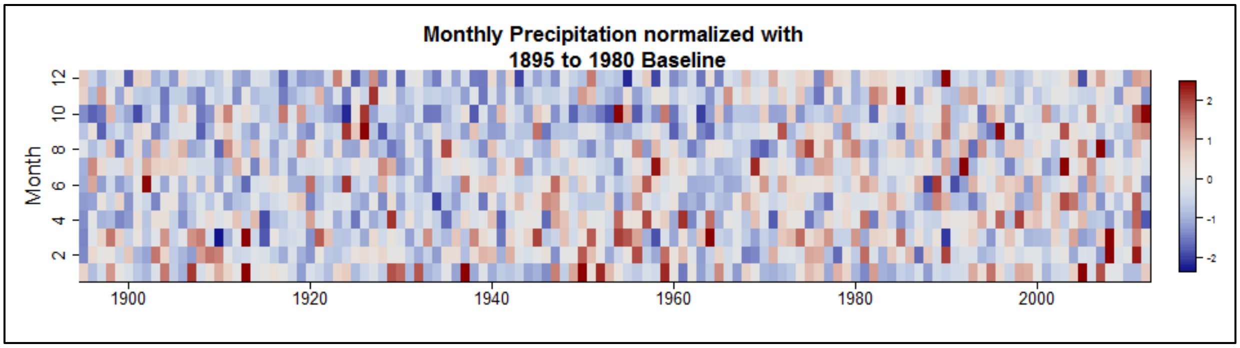

Figure 4.4-6. Mean monthly precipitation showing the normalized difference from a baseline (1895–1980) period for each month and year for Cuyahoga Valley National Park. The baseline is calculated monthly within the specified year range. The pixels are normalized by month and colors range from +/− 2.5 standard deviations from the mean of the baseline period. (Data and graphic prepared by NCCSC).

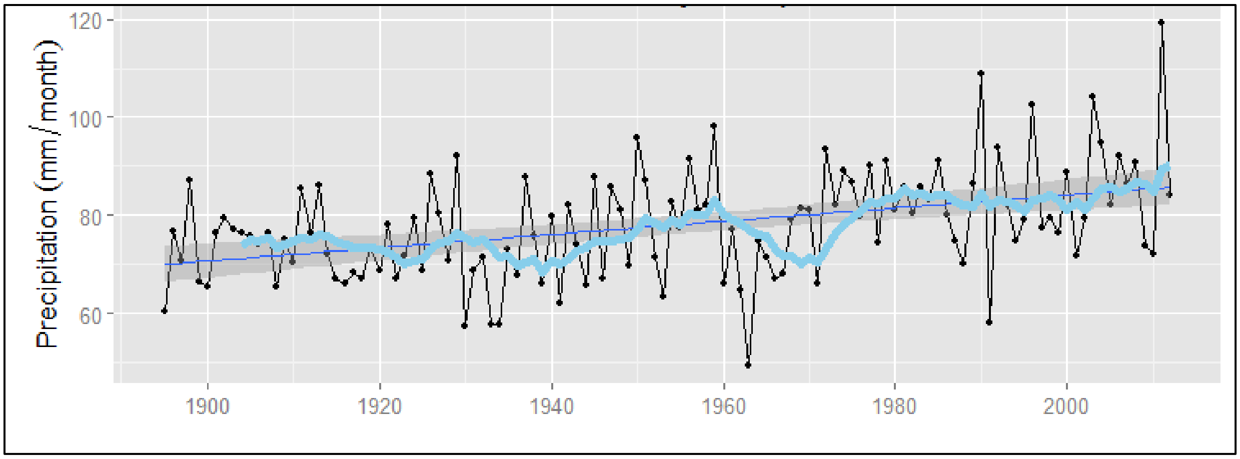

Figure 4.4-7. Historic PRISM data for precipitation at Cuyahoga Valley National Park showing linear model fit and a five year lag running mean. (Data and graphic prepared by NCCSC).

In recent decades there have been increases nationally in the annual amount of precipitation falling in very heavy events, defined as the heaviest 1% of all daily events from 1901 to 2012. The largest regional increases have been in the Midwest and Northeast when compared to the 1901–1960 average (Walsh et al. 2014b). Regional results for the Midwest region including CUVA indicate an increase of 20 to 30% or more in the annual amount of precipitation falling in very heavy events over the past few decades (Figure 4.4-8).

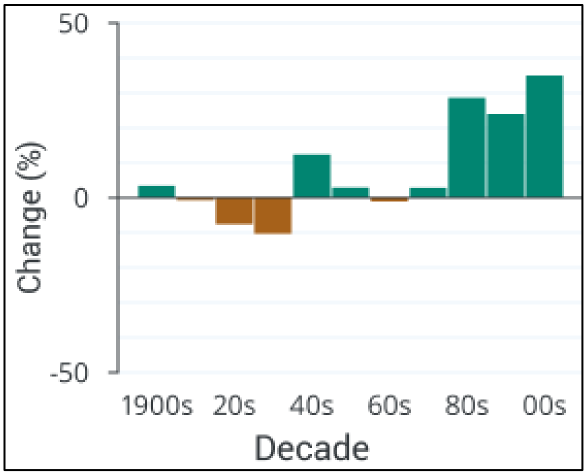

Figure 4.4-8. Percent changes in the annual amount of precipitation falling in very heavy events compared to the 1901–1960 average for the Midwest region. A very heavy event is defined as the heaviest 1% of all daily events from 1901 to 2012. The far right bar is for 2001–2012 (Walsh et al. 2014b).

Modeled Future Changes

Modeled climate through the year 2100 shows an increase in mean monthly precipitation under both moderate (RCP4.5) and high (RCP8.5) emission scenarios (Figure 4.4-9). Both the medium and high emission scenarios produce higher mean monthly precipitation compared to the baseline period, with increases of approximately 5–6 mm (0.19–0.24 inches) per month or approximately 60–72 mm (2.36–2.83 inches) per year by the 2040s and 5–12 mm (0.19–0.47 inches) per month or approximately 60–144 mm (2.36–5.67 inches) per year by the 2080s.

Aridity

Aridity and moisture availability are examined using the Palmer Drought Severity Index (Palmer 1965) for the historic 1895–2013 period. No modeled future events are considered for aridity due to a lack of well supported tools to examine this indicator's potential for change.

Historic Trends

Palmer Drought Severity Index (PDSI) values were calculated for the period from 1895 to 2013 (Figure 4.4-10). The Palmer Index is most effective in determining long term drought (i.e., at least several months). Long-term drought is cumulative, so the intensity of drought during a point in time is dependent on the current weather patterns plus the cumulative patterns of the previous period. PSDI values range between −4.00 or less (extreme drought) and +4.00 or greater (extreme moisture). The index uses a value of 0 as "normal", and value of −1.5 is considered drought. While drought is sometimes described as cyclic, the frequency and duration of cycles is highly unpredictable. For the period of record, CUVA PDSI data shows periodic moderate to severe drought lasting 2–6 years occurring approximately every 30 years since about 1900. Wet periods occur more frequently but with less intensity than drought periods.

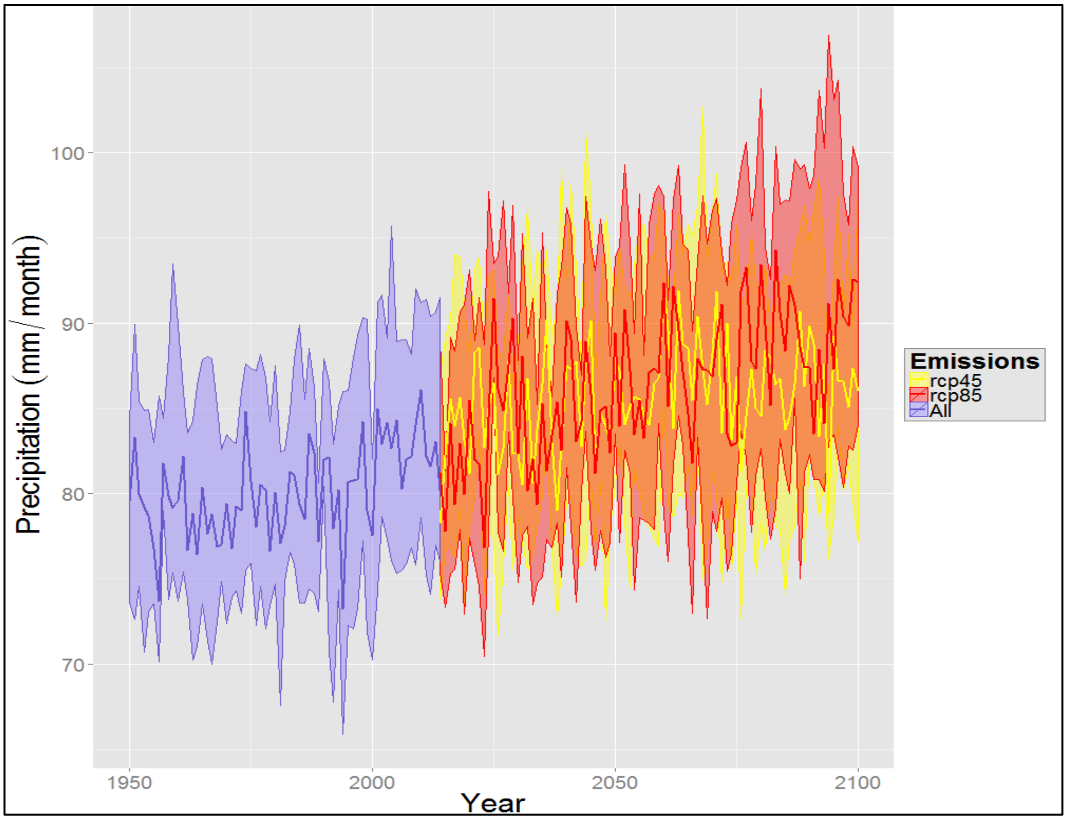

Figure 4.4-9. Projections for precipitation/month with mean, 25% and 75% quantiles grouped by emissions scenario for Cuyahoga Valley National Park. (Data and graphic prepared by NCCSC).

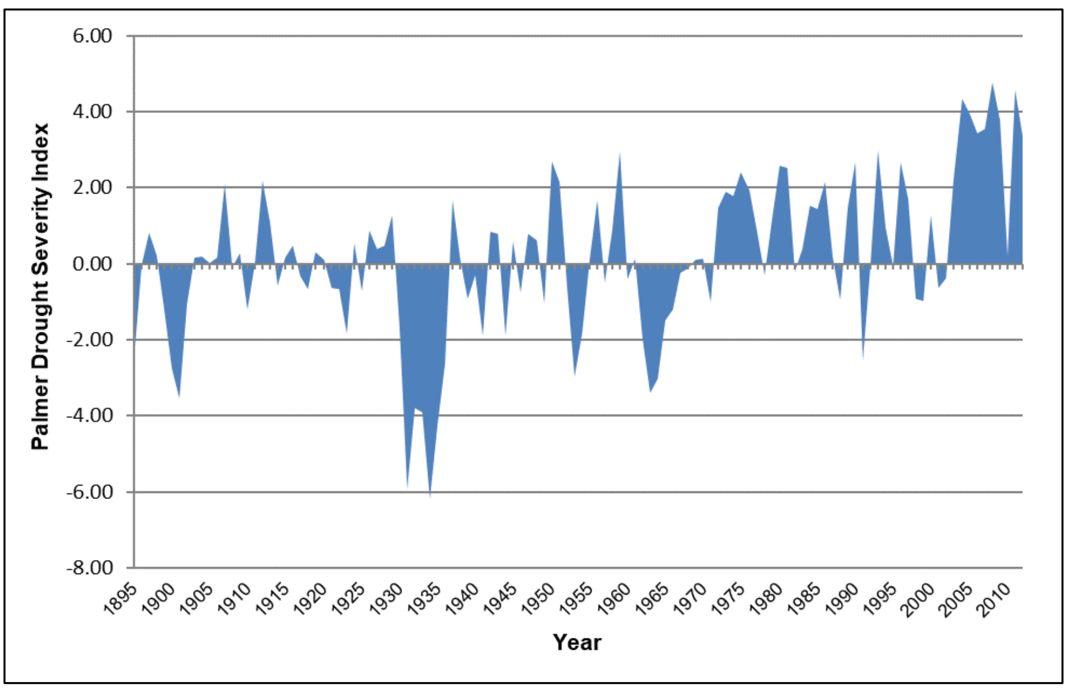

Figure 4.4-10. Palmer Drought Severity Index from 1895 –2013 for Cuyahoga Valley National Park. Negative values represent dry conditions and positive values represent moist conditions (NCDC 2018).

Frost-Free Period

Historic Trends

The last frost in the spring has been occurring earlier in the year, and the first frost in the fall has been happening later. In the Midwest region, the average frost-free season for 1991–2011 was about 9 days longer than during 1901–1960 (Walsh et al. 2014b). A longer growing season can increase carbon sequestration in plants (Peñuelas et al. 2009) and increase the growth of both desirable and undesirable plants.

Modeled Future Changes

By the 2070–2099 period, the frost-free season for the Midwest is projected to rise significantly as heat-trapping gas emissions continue to grow, increasing by 20–30 days under the lower emissions (B1) scenario and 40–50 days under the higher (A2) emissions scenario compared to the 1971–2000 baseline period (Melillo et al. 2014).

Overall Assessment

Indications are that the climate in this park region is already becoming wetter, hotter, and is potentially more prone to more frequent and extreme weather events. Trends in the indicators are projected to continue or accelerate by the end of the century. Because these changes in the environment are beyond the control of park managers and climate is not a conventional resource to be managed, climate change is not evaluated using the condition status and trend framework applied in this condition assessment. Research and monitoring related to climate change, the anticipated vulnerability of specific resources vis-a-vis climate change, and its associated effects on resources and interaction with other ecological processes can be informed by this broad overview of the magnitude of climate change in the park region.

4.4.5. Management and Ecological Implications

Changing climate is anticipated to impact Midwestern forests in a number of ways, and is likely to compound the effects of existing stressors and increase the vulnerability of forests to pests, invasive species and loss of native species (NFWPCAP 2012). Species ranges and ecological dynamics are already responding to recent climate shifts, and current reserves including NPS units will be unable to support all species, communities and ecosystems (Heller and Zavaleta 2009), some of which form the core of their park mission.

Resources vulnerable to climate change at Cuyahoga Valley National Park (CUVA) include the temperate mixed forest ecosystem (Gonzalez 2012). Although numerous species at CUVA are vulnerable to climate change, black ash (*Fraxinus nigra*), quaking aspen (*Populus tremuloides*), eastern hemlock (*Tsugu canadensis*) and bur oak (*Quercus macrocarpa*) may become extirpated from the park even under relatively minor changes in climate (NPS 2015a) (See Section 4.7).

The climate suitable for temperate deciduous forest is expected to remain relatively stable with some expansion to the north into the Canadian Taiga (Rehfeldt et al. 2012). Although when looking at ecoregions in finer detail, a shift from temperate mixed forest to temperate broadleaf forest may occur (Gonzalez 2012). Increasing CO_2 tends to increase plant growth and water use efficiency, but may be limited by water and nutrient availability. Transpiration rates usually decline as CO_2

increases, while, in many plants, photosynthesis and growth increase. Growth response to CO_2 is usually highest in rapidly-growing plants and in plants with the C3 photosynthetic pathway (most woody plants and "cool-season" grasses) versus the C4 pathway (most "warm-season" grasses) which could lead to an increase in the growth rates of tree species prevalent at CUVA (Schramm 2011).

Studies of the northeast forest system show that changes in plant abundance are highly correlated with the flowering season, which has been occurring earlier in the year in North America (Willis et al. 2008, Hayhoe et al. 2007, Parmesan 2006). A longer growing season could lead to increased wood production and decreased root and foliar mass in northeastern forest trees altering water uptake capabilities during droughts and effecting evapotranspiration rates (Campbell et al. 2009). Biogeochemical cycling in forested areas could also be impacted due to a shift from a mixed forest containing coniferous trees to a more broadleaf dominated deciduous forest, whose litter decomposes faster and has more biotic activity than that of coniferous litter (Campbell et al. 2009).

Other key potential ecological impacts and management implications of climate change in the eastern deciduous forest region and at CUVA include:

- Extreme streamflow events are expected to increase, with a shift toward higher flows in the winter and spring, and lower flows in summer and fall (Schramm 2011);
- Increasing temperatures cause an increase in evaporation, which will take place mostly in the summer, potentially increasing the vulnerability of organisms in the region to drought in combination with other factors including altered precipitation, runoff, and soil moisture (Hayhoe 2007);
- Less predictable winter temperature and precipitation patterns interposed by warm spells could cause trees and other plants to bud and leaf out earlier, increasing their vulnerability to late-season freezes (Hayhoe 2007);
- Higher temperatures could affect phenological events such as flowering, fruit set, and seed production. Longer growing seasons could increase wood production at the expense of root and foliar mass (Hayhoe 2007);
- Warmer temperatures may increase the negative effects of ozone pollution on forest growth and health and increase vulnerability to disease (USDA 2001);
- An interruption in the timing of lifecycles between predators and prey may have a large impact on wildlife (Parmesan 2006);
- Bird species of eastern forests have a higher vulnerability to climate change than birds in western, boreal, or subtropical forests. Approximately 75% of eastern forest bird species that live in a single forest type are moderately or highly vulnerable to climate change (NABCI 2010);

- Increased temperatures can increase the metabolism, reproductive rates, and survival of nuisance species (Dukes et al. 2009), including the black-legged tick (*Ixodes scapularis*) which is a carrier of the bacteria that causes Lyme disease (Gatewood et al. 2009). Another nuisance species specific to CUVA that could be bolstered by climate change is the hemlock wooly adelgid (*Adelges tsugae*), a pest that is already linked to a reduction in hemlock populations (Dukes et al. 2009);
- An increase in the growth, reproduction, dispersal, transmission, infection phenology, and overwinter survival of some forest pathogens could be increased by climate change (Schramm 2011);
- Increases in invasive exotic plants (NFWPCAP 2012);
- More frequent extreme events such as heat waves and heavy rains (Karl et al. 2009), and increasing likelihood of flooding in the wetter, northern portions of the Midwest (Walsh 2014b);
- Limited ability for species and communities to adapt; the relatively flat terrain characterizing these forests increases vulnerability to climate change because species and habitats may be obliged to migrate long distances to compensate for temperature shifts. This challenge is exacerbated by the highly fragmented and altered landscape in the region (Schramm 2011); and
- Climate change is likely to exacerbate existing stressors related to anthropogenic disturbances at landscape scales including energy development and agriculture that fragment the landscape and hinder species adaptation (Bagne et al. 2013, Shaeffer et al. 2014).

It is increasingly clear that given significant shifts in climatic variables, adaptation efforts will need to emphasize managing for inevitable ecological changes and concurrently adjusting some management objectives or targets (Stein et al. 2013). In a review of articles examining biodiversity conservation recommendations in response to climate change, Heller and Zavaleta (2009) synthesized conservation recommendations with regard to regional planning, site-scale management, and modification of existing conservation plans. They found that most recommendations offer general principles for climate change adaptation but lack specificity needed for implementation. Specific adaptation tools and approaches will undoubtedly help park managers with these challenges. Adaptation approaches need to be intentional, context-specific and based on a deliberative process, rather than selected from a generic menu of options (Stein et al. 2014).

While climate change cannot be controlled by the park, managers can take steps to minimize the severity of exposure to these changes and help conserve sensitive resources as the transition continues. Existing condition analyses and data sets developed by this NRCA will be useful for subsequent park-level climate change studies and planning efforts.

4.4.6. Uncertainty and Data Gaps

Climate change projections have inherently high uncertainty. Confidence is higher in modeled temperature dynamics and lower for modeled precipitation totals and seasonal patterns. The largest uncertainty in projecting climate change beyond the next few decades is the level of heat-trapping gas emissions (Walsh et al. 2014a). Information gaps to help manage resources and understand the repercussions of climate change to the park include the need for: 1) more specific, applied examples of adaptation principles that are consistent with uncertainty about the future; 2) a practical adaptation planning process to guide selection and integration of recommendations into existing policies and programs; and 3) greater integration of social science and extension of adaptation approaches beyond park boundaries (Heller and Zavaleta 2009).

4.4.7. Sources of Expertise

- Jeffrey Morisette (Director, DOI North Central Climate Science Center). Provided data and expertise regarding modeled climate and metrics.
- Marian Talbert, Biostatistician, DOI North Central Climate Science Center. Provided data and expertise regarding modeled climate and metrics.
- John Gross, Climate Change Ecologist, NPS Inventory and Monitoring Program National Office. Provided expertise regarding modeled climate and metrics and discussing appropriate metrics to include in NRCAs.

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4.5. Air Quality

4.5.1. Background and Importance

The NPS Organic Act, *Air Quality Management Policy 4.7.1*, and the Clean Air Act of 1977 and its subsequent amendments protect and regulate the air quality of the National Parks within the United States. The NPS is responsible for protecting air quality and related issues which may be impacted by air pollution. Many resources in parks can be affected by air pollution. For example, scenic vistas require good visibility and low haze. Human-made pollution can harm ecological resources, including water quality, plants and animals. Air pollution can also cause or intensify respiratory symptoms for visitors and employees at NPS areas. Because of these many links, poor and/or declining air quality can impact park visitation. A synthesis of seven visitor studies conducted in the NPS Midwest Region found that clean air was ranked as *extremely important* or *very important* by 88% of visitor groups (Kulesza et al. 2013).

National Park Service units fall under two different classifications for air quality protection. Class I airsheds are defined as national parks over 6,000 acres (2,428 ha), national wilderness areas, national memorial parks over 5,000 acres (2,023 ha), or international parks in existence as of August 7, 1977 (NPS ARD 2013). Class II airsheds are areas of the country protected under the Clean Air Act, but identified for somewhat less stringent protection from air pollution damage than a Class I area, except in specified cases (NPS ARD 2013). Based on these classifications of airsheds, CUVA falls under the Class II area of protection.

Air quality can have a significant impact on the vegetation and ecology of an area. The NPS Air Resources Division describes ground-level ozone as having a larger effect on plants than all other air pollutants combined. While there are no data that suggest that soils or surface waters at CUVA have done so (Sullivan 2016), Nitrogen (ammonia – NH_4) and Sulfur (sulfate – SO_3) deposition can cause acidification of water bodies, while excess nitrate (NO_3) can lead to nutrient effects on biodiversity. Decreased visibility from haze does not affect the ecology of an area so much as it affects the human element through decreased viewing opportunities of the protected lands and surrounding areas

As of February 2018, the CUVA area was listed by EPA as maintenance area for ozone levels. Maintenance areas are former nonattainment areas that have improved air quality enough to meet EPA standards (EPA 2018). CUVA experiences "Very High" exposure to atmospheric Nitrogen (N) enrichment and has been described as being at high risk from N enrichment (Sullivan et al. 2011a). CUVA also has "Very High" exposure to acidic deposition from Sulfur (S) and N emissions and has been described as being highly at risk from acidic deposition (Sullivan et al. 2011b).

Threats/ Stressors

The Ohio Environmental Protection Agency (OEPA) has listed Cuyahoga County (which CUVA partially lies in) as having high levels of particulates, sulfur dioxide, nitrogen dioxide, ozone, and lead (OEPA 2014). Summit County, which contains the rest of CUVA, is listed by the OEPA as having high levels of $PM_{2.5}$, sulfur dioxide, and ozone (OEPA 2014). CUVA is situated in between the major industrial cities of Cleveland and Akron, Ohio, which largely explains its degraded air quality.

Indicators and Measures

- Ozone: human health risk
- Ozone: vegetation health risk
- Atmospheric wet deposition of nitrogen
- Atmospheric wet deposition of sulfur
- Visibility haze index

4.5.2. Data and Methods

The condition of air quality within CUVA was assessed using methodology developed by the NPS ARD for use in Natural Resource Condition Assessments (Taylor 2017). NPS ARD uses all available data from NPS, EPA, state, and/or tribal monitoring stations to interpolate air quality values, with a specific rating assigned to the maximum daily value within each park. Even though the data are derived from all available monitors, data from the closest stations "outweigh" the more distant stations.

Trends are computed from data collected over a 10-year period at on-site or nearby representative monitors. Trends are calculated for sites that have at least six years of annual data and an annual value for the end year of the reporting period. Currently, there are no representative monitoring stations for ozone, wet deposition, or visibility located within or near CUVA to assess 10-year trends. Monitoring data originates from regional monitoring stations and interpolated values. Ozone is monitored at two stations in the region in Akron, OH (10 miles south of the park) and in Cleveland, OH 15 miles north of CUVA. Wet deposition is monitored in Wooster, OH 30 miles southwest of the park. There is an Interagency Monitoring of Protected Visual Environments (IMPROVE) visibility monitoring station 90 miles east of the park in western Pennsylvania (CIRA 2018).

Condition and trend data were retrieved from the NPS *Air Quality Conditions and Trends by Park* database (NPS ARD 2017).

Reference Conditions

Reference conditions are based on regulatory standards, best available scientific knowledge, or recommendations by NPS ARD (Taylor 2017). A summary of reference conditions and a condition class rating framework for air quality indicators is shown in Table 4.5-1.

Ozone: Human Health Risk

The primary National Ambient Air Quality Standard (NAAQS) for ground-level ozone is set by the EPA and is based on human health effects. The 2008 NAAQS for ozone was set at 75 ppb for the 3-year average of the 4th-highest daily maximum 8-hour average ozone concentration. On October 1, 2015, the EPA strengthened the national ozone standard by setting the new level at 70 ppb. The NPS ARD benchmarks for the human health risk from ozone status are based on the updated Air Quality Index (AQI) breakpoints. The status for human health risk from ozone is based on the estimated 5-year average of the 4th-highest daily maximum 8-hour average ozone concentration compared to benchmarks. Ozone concentrations greater than or equal to 71 ppb warrant significant concern, concentrations from 55–70 ppb warrant moderate concern category, and ozone concentrations less than or equal to 54 ppb are considered good condition (Table 4.5-1) (Taylor 2017).

Table 4.5-1. Reference condition framework for air quality indicators (Taylor 2017).

Air Quality Indicator	Specific Measure	Good Condition	Moderate Condition	Poor Condition
Ozone	Human Health: Annual 4th-highest 8hr concentration	≤ 54 ppb	55–70 ppb	≥ 71 ppb
	Vegetation Health: 3-month maximum 12hr W126	< 7 ppm-hrs	7–13 ppm-hrs	> 13 ppm-hrs
Visibility	Haze Index	< 2 dv	2–8 dv	> 8 dv
Nitrogen	Wet Deposition	<1 kg/ha/yr	1–3 kg/ha/yr	> 3 kg/ha/yr
Sulfur	Wet Deposition	<1 kg/ha/yr	1–3 kg/ha/yr	> 3 kg/ha/yr

Ozone: Vegetation Health Risk

The W126 metric is a biologically relevant measure that focuses on plant response to ozone exposure. This measure is a better predictor of vegetation response than the metric used for the human health standard. The W126 metric equation preferentially weights the higher ozone concentrations that are more likely to cause plant damage. It sums all of the weighted concentrations during daylight hours as this is when the majority of gas exchange occurs between the plant and the atmosphere. The highest 3-month period that occurs during the growing season is reported in parts per million-hours (ppm-hrs).

The status for vegetation health risk from ozone is based on the estimated 5-year average of the 3-month 12-hour W126 index compared to benchmarks. A W126 index greater than 13 ppm-hrs is assigned a *Warrants Significant Concern* status. A W126 index from 7–13 ppm-hrs is assigned *Warrants Moderate Concern* status. Resource is in *Good Condition* if the W126 index is less than 7 ppm-hrs (Table 4.5-1) (Taylor 2017).

Wet Nitrogen Deposition

The NPS ARD (Taylor 2017) considers parks that receive less than 1 kg/ha/yr of nitrogen each as being in “Good Condition”. Parks receiving between 1–3 kg/ha/yr are ranked as “Moderate Condition”. Those parks which receive greater than 3 kg/ha/yr are ranked as “Poor Condition” (Table 4.5-1) (Taylor 2017).

Wet Sulfur Deposition

The NPS ARD (Taylor 2017) considers parks that receive less than 1 kg/ha/yr of sulfur each as being in “Good Condition”. Parks receiving between 1–3 kg/ha/yr are ranked as “Moderate Condition”. Those parks which receive greater than 3 kg/ha/yr are ranked as “Poor Condition” (Table 4.5-1) (Taylor 2017).

Visibility
Visibility is measured using the Haze Index in deciviews (dv). Visibility conditions are the difference between the mid-range day visibility and estimated average natural visibility, where the mid-range day's natural visibility is the mean between the 40th and 60th percentiles (Taylor 2017). Five-year interpolated averages are used in the contiguous US. Visibility is considered to be in "Good Condition" if visibility is less than 2 dv, "Moderate Condition" if between 2–8 dv, and "Poor Condition" if greater than 8 dv (Table 4.5-1) (Taylor 2017).

4.5.3. Condition and Trend

Ozone: Human Health Risk
Ozone causes problems for human health, including difficulty breathing, chest pain, coughing, inflamed airways, and making lungs more susceptible to infection (EPA 2017). From 2011–2015, CUVA experienced a 4th highest 8-hr ozone average concentration of 69.3 parts per billion (ppb) (NPS ARD 2017). For 2006–2015, the trend in ozone concentration at CUVA improved (AQS Monitor ID: 391530020, OH) (NPS ARD 2017). This most recent air quality data indicates moderate condition for ozone levels with an improving trend and high confidence due to an on-site or nearby ozone monitor (NPS ARD 2017).

Ozone: Vegetation Health Risk
In addition to being a concern to the health of park staff and visitors, long-term exposures to ground-level ozone can cause injury to ozone-sensitive plants. There are 58 plant species identified within CUVA that are sensitive to ozone (Bell et al. 2020). Ozone is able to enter leaves through stomata and causes chlorosis and necrosis of leaves (Figure 4.5-1), among other problems. Soil moisture plays a big role in the uptake of ambient ozone. Moist soils allow plants to transpire and increase stomatal conductance which, in turn, increases ozone uptake (Panek and Ustin 2004). A risk assessment concluded that plants in CUVA were at high risk for ozone damage (Kohut 2007).

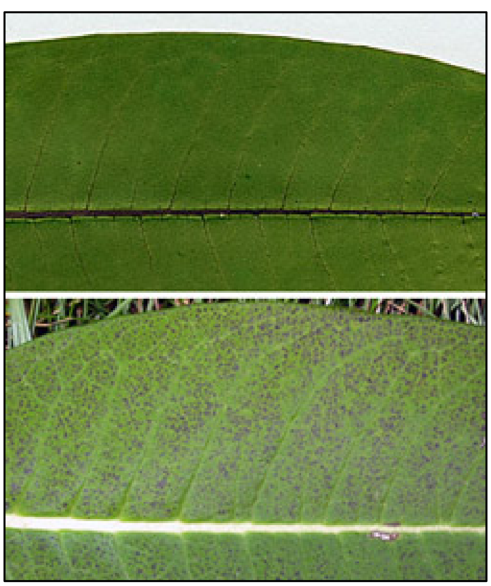


Figure 4.5 1. *Asclepias syriaca* normal leaf (top) and ozone-injured leaf (bottom). Photo: NPS ARD.

Based on the 2011–2015 estimated W126 metric of 8.4 ppm-hrs, for 2006–2015 the trend in the W126 metric at Cuyahoga Valley NP improved (AQS Monitor ID: 391530020, OH) (NPS ARD 2017). Overall, the vegetation health risk from ground-level ozone is in moderate condition with an improving trend and high confidence due to an on-site or nearby ozone monitor (NPS ARD 2017).

Wet Nitrogen Deposition

Based on the 2011–2015 estimated wet nitrogen deposition of 5.4 kg/ha/yr, wet nitrogen deposition falls in the poor condition with medium confidence due to the regional and modeled nature of the data. No trend information is available because there are not sufficient on-site or nearby visibility monitoring data (NPS ARD 2017).

Wet Sulfur Deposition

Based on the 2011–2015 estimated wet sulfur deposition of 3.7 kg/ha/yr, wet sulfur deposition falls in the poor condition category with medium confidence due to the regional and modeled nature of the data. No trend information is available because there are not sufficient on-site or nearby visibility monitoring data (NPS ARD 2017).

Visibility

Based on the 2011–2015 estimated visibility on mid-range days of 9.0 dv, the visibility condition falls in the poor condition category with medium confidence due to regional and modeled nature of data. No trend information is available because there are not sufficient on-site or nearby visibility monitoring data (NPS ARD 2017).

Overall Condition

Based on the evaluation of air quality indicators, air quality condition warrants significant concern, with an improving trend (Table 4.5-2). Confidence in the assessment is medium. Impacts to air quality appear to be largely from off site and distant sources that are affecting regional air quality.

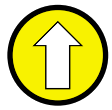
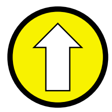
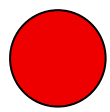
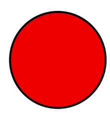
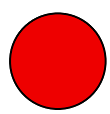
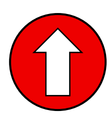
4.5.4. Uncertainty and Data Gaps

Monitoring stations are needed within CUVA to better understand the specific air quality conditions at the property. Estimated values based on geospatial interpolations are adequate, but can misrepresent park conditions due to modeling errors. Monitoring of air quality conditions within CUVA or nearby would reduce uncertainty from the interpolations for all non-ozone related indicators.

4.5.5. Sources of Expertise

The National Park Service's Air Resources Division oversees the national air resource management program for the NPS. Together with parks and NPS regional offices, they monitor air quality in park units, and provide air quality analysis and expertise related to all air quality topics. Preliminary drafts of this section were reviewed by CUVA staff. For current air quality data and information for this park, please visit the NPS Air Resources Division website at www.nps.gov/subjects/air/index.htm.

Table 4.5-2. Condition assessment summary for air quality at Cuyahoga Valley National Park.

Indicator	**Measure**	**Condition Status/Trend**	**Rationale**
Ozone	Human Health: Annual 4^{th}-highest 8hr concentration		Human health risk from ground-level ozone warrants moderate concern at CUVA. This status is based on NPS Air Resources Division benchmarks and the 2011–2015 estimated ozone of 69.3 parts per billion (ppb).
	Vegetation Health: 3-month maximum 12hr W126		Vegetation health risk from ground-level ozone is in moderate condition at CUVA. This status is based on NPS Air Resources Division benchmarks and the 2011–2015 estimated W126 metric of 8.4 parts per million-hours (ppm-hrs). The W126 metric relates plant response to ozone exposure. A risk assessment concluded that plants in at the park were at high risk for ozone damage (Kohut 2007).
Visibility	Haze Index		Visibility warrants significant concern at CUVA. This status is based on NPS Air Resources Division benchmarks and the 2011–2015 estimated visibility on mid-range days of 9.0 deciviews (dv) above estimated natural conditions[3].
Nitrogen	Wet Deposition		Wet nitrogen deposition warrants significant concern at CUVA. This status is based on NPS Air Resources Division benchmarks and the 2011–2015 estimated wet nitrogen deposition of 5.4 kg/ha/yr. Nitrogen deposition may disrupt soil nutrient cycling and affect biodiversity of some plant communities, including grasslands and wetlands.
Sulfur	Wet Deposition		Wet sulfur deposition warrants moderate concern at CUVA. This status is based on NPS Air Resources Division benchmarks and the 2011–2015 estimated wet sulfur deposition of 3.7 kg/ha/yr.
Air Quality overall	–		**The condition of air quality indicators warrants significant concern with an improving trend. Confidence in the assessment is medium.**

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4.6. Water Quality

4.6.1. Background and Importance

Surface waters at Cuyahoga Valley National Park (CUVA) include the Cuyahoga River, 70 ponds and lakes ranging in size from 1/10th of an acre to 12 acres, over 1,500 verified wetlands, and 11 large watersheds (43 subwatersheds) of the Cuyahoga River with many perennial headwater streams (NPS 2018a). Major tributaries to the Cuyahoga River within the park are listed in Table 4.6-1. The Cuyahoga River was a significant participant in the history of water quality monitoring and of the beginning of the environmental movement in general in the United States in the late 1960s and early 1970s. Infamously known as "the river that burned", a large fire on the Cuyahoga River in June 1969 prompted the United States government to begin drafting legislation to correct the country's air and water quality problems. While the river still has water quality issues, as a whole, the Cuyahoga River's water quality has significantly improved since these events.

Table 4.6-1. Watersheds and associated tributaries within the CUVA area of analysis for water quality (listed upstream to downstream along the mainstem Cuyahoga River). Data from Cuyahoga River Restoration (2015).

Tributary Name	Watershed (HUC)	Drainage Area (mi^2)
Little Cuyahoga River	City of Akron – Little Cuyahoga River (041100020304)	19.7
Boston Run	Boston Run – Cuyahoga River (041100020405)	46.4
Mud Brook	Mud Brook (041100020401)	29.8
Yellow Creek	Yellow Creek (041100020402)	31.2
Furnace Run	Furnace Run (041100020403)	20.3
Brandywine Creek	Brandywine Creek (041100020404)	27.1
Sagamore Creek/Run	Willow Lake – Cuyahoga River (041100020505)	24.2
Chippewa Creek	Headwaters Chippewa Creek (041100020503)	17.8
Tinker's Creek	Town of Twinsburg – Tinker's Creek (041100020504)	55.5
None[a]	Village of Independence – Cuyahoga River (041100020602)	17.0
West Creek	Town of Cuyahoga Heights – Cuyahoga River (041100020604)	19.1

[a] No major tributaries affiliated with this watershed, mainstem Cuyahoga River only.

Cuyahoga River water quality is largely affected by stormwater discharge, combined-sewer overflows, and incomplete treatment of wastewater from urban areas (Bushon and Koltun 2004). Draining an area of 813 square miles in northeastern Ohio (Figure 4.6-1), the Cuyahoga River is over 100 miles long, with 22 of those miles flowing through CUVA (Plona and Skerl 2008). The section of the Cuyahoga River that runs through CUVA is in Summit and Cuyahoga Counties and is surrounded by a matrix of suburban, exurban, agricultural and industrial land uses.

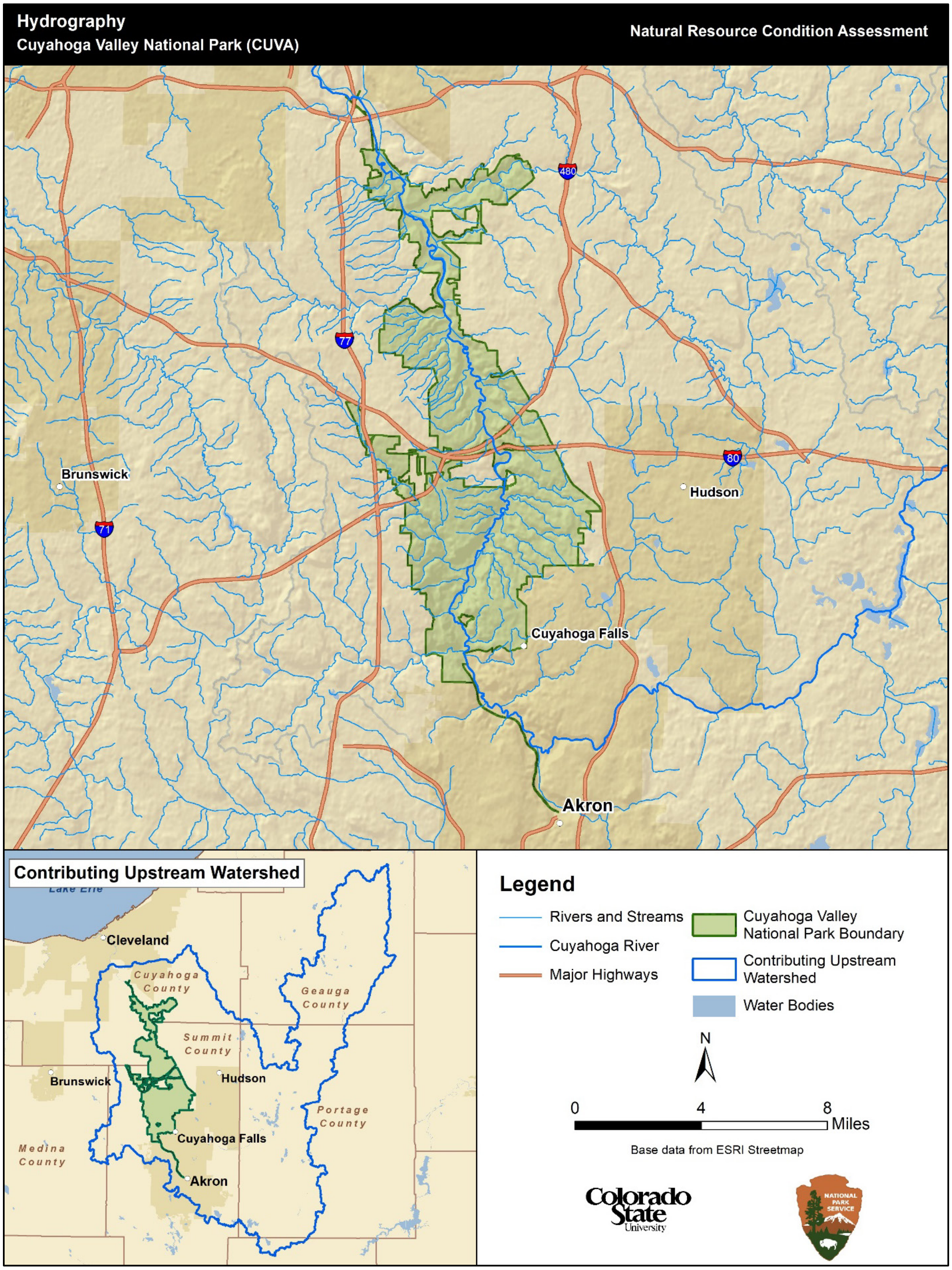


Figure 4.6-1. Hydrography of Cuyahoga Valley National Park and surroundings (base data from ESRI Streetmap).

Cuyahoga River (photo by Dave Jones, CSU)

The federal Clean Water Act (as amended 1972) requires states to adopt water quality standards to protect lakes, streams, and wetlands from pollution. The standards define how much of a pollutant can be in the water while still meeting designated uses, such as drinking, fishing, and swimming. A water body is “impaired” if it fails to meet one or more water quality standards. To identify and restore impaired waters, Section 303(d) of the Clean Water Act requires states to assess all waters to determine if they meet water quality standards, list waters that do not meet standards (also known as the 303d list) and update the list every even-numbered year, and conduct total maximum daily load (TMDL) studies to establish pollutant-reduction goals needed to restore waters. Federal and state regulations and programs also require implementation of restoration measures to meet TMDLs. Delisting of impaired waters only occurs when new and reliable data indicates that the waterbody is no longer impaired.

Several tributaries to the Cuyahoga River and much of the mainstem flowing through the park and into Lake Erie are on the Section 303(d) list (OEPA 2018). Despite the impaired nature of many stream reaches, several tributaries have been designated by the State of Ohio as “superior high quality waters” (Furnace Run, North Fork Yellow Creek, and Yellow Creek)(OEPA 2017) and the Cuyahoga River is widely recognized for its aesthetic and recreational value. The mainstem Cuyahoga River running through much of the park has been designated as one of only two rivers labeled as “outstanding state waters based on exceptional recreational values” (OEPA 2018).

As one of several Great Lakes waterways recognized by the U.S.-Canada Great Lakes Water Quality Agreement as failing to meet objectives of this international treaty, the Cuyahoga River Area of Concern (AOC) has been the beneficiary of large-scale efforts to improve water quality and aquatic habitat since the 1980s. In 1988, a diverse set of stakeholders including the Ohio EPA, the Cuyahoga River Community Planning Organization, state and municipal government agencies, and several smaller watershed groups developed plans to remove the AOC from this list of impaired waters, also known as “delisting” (Cuyahoga River Restoration 2015). These efforts have substantially improved the water quality of the AOC, and reports requesting the delisting of portions of the watershed have been released in recent years (Cuyahoga River Restoration 2015, CRRAPCC 2009)

Threats and Stressors

Stressors to the water quality of the Cuyahoga River and its tributaries within the park come from a combination of point and non-point sources, with combined sewer overflows from the City of Akron potentially having the most impact within the park. Urbanization in several watersheds has caused altered stream hydrology and increased nutrient enrichment. Increased impervious surface area and storm water infrastructure has resulted in increased erosion and deposition, as well as higher levels of petroleum/oils/lubricants, nutrients, and pesticides in local streams. Combined sewer overflows can result in increased debris and litter, odor, dissolved oxygen depletion, and excessive bacteria levels (OEPA 2003). Mercury and PCB's present in the river system have led to fish consumption advisories (NPS 2018b)

Indicators and Measures

Analyzing the condition of aquatic life is a major focus of the monitoring of water quality for the Ohio EPA (OEPA 2014). The state of Ohio uses an innovative approach to the monitoring of water quality and assessment of biological condition in its water bodies. This system uses biological indices in addition to more traditional methods of water quality monitoring such as chemical analysis. Relying solely on chemical and physical stressors and exposure data while ignoring the direct measurement of biological response due to these stressors has led to an inadequate foundation for water resource management in many states and localities (Yoder and Rankin 1998). Due to the success of the Clean Water Act, point source pollution has generally declined; other chemical/physical stressors such as nonpoint source pollution and habitat degradation are more difficult to assess by direct measurement of water chemistry alone (Yoder and Rankin 1998). In Ohio, as calculated in 1998, the use of biocriteria in water quality monitoring resulted in the identification of 50% more impaired waters than using a water chemistry approach alone (Yoder and Rankin 1998). With the exception of *Escherichia coli* concentrations (for recreational contact), the analyses used in this section will be based on these alternate water quality criteria.

Aquatic Life Use (IBI, MIwb)

The OEPA uses a tiered system of aquatic life uses to assign numerical criteria to a water body based on natural ecological variability while considering the effects of 200 years of intensive land use in Ohio. (Yoder and Rankin 1998, OEPA 2018). These aquatic life uses are assigned to water bodies or stream segments based on the potential of that site to support a specific assemblage of species according to numerical and narrative criteria (OEPA 2018). The tiered system for warm water aquatic habitats goes from lowest biological integrity (Limited Resource Water (LRW)) to highest biological integrity (Exceptional Warmwater Habitat (EWH)). Most water bodies in Ohio fall into the Warmwater Habitat (WWH) category, as do most watersheds in the vicinity of CUVA and addressed by our evaluation. Paragraph (B)(1)(a) of rule 3745-1-07 of the Ohio Administrative Code describes the warmwater aquatic life habitat designation as "waters capable of supporting and maintaining a balanced, integrated, adaptive community of warmwater aquatic organisms" (OEPA 2014).

Seven tributaries within CUVA boundaries have been designated as Coldwater Habitat (OEPA 2017). Waterbodies listed as Coldwater Habitat (CWH) in the State of Ohio "support assemblages of coldwater organisms and/or are stocked with salmonids" (OEPA 1999). Within CUVA, Boston Run, Salt Run, Langes Run, Robinson Run, Woodward Creek, Slipper Run and portions of Sagamore Creek are all designated as CWH (OEPA 2017). There was insufficient data to analyze CWH separately from other streams for the NRCA.

The biological community indicators used by the OEPA include the Index of Biological Integrity (IBI), the Modified Index of well-being (MIwb), and the Invertebrate Community Index (ICI). IBI and ICI are multi-metric indices modelled after the IBI described by Karr (1981) and Fausch et al. (1984). The MIwb measures fish community abundance and diversity and is a modified version of the Index of well-Being applied by Gammon (1976). Methods for implementing MIwb are described in OEPA (2015). For more information on Aquatic Life Use designations and their criteria and status in Ohio, see OEPA (2014a).

Coliform bacteria (E. coli)

Coliform bacteria are measured by total coliform through a laboratory test examining the number of bacteria colonies that grow on a prepared medium (USGS 2016). Fecal coliforms and E. coli are coliform bacteria found in the intestinal tract of warm-blooded animals such as humans and livestock. The presence of fecal coliform bacteria in water suggests the presence of fecal matter and associated harmful bacteria (e.g., some strains of *E. coli*), viruses and protozoa (e.g., Giardia and Cryptosporidium) that are pathogenic to humans when ingested (EPA 2017). Coliform bacteria can cause a variety of illnesses and have been used to establish microbial water quality criteria (USGS 2016). CUVA, USGS, and the Cuyahoga River Area of Concern (designated by the 1987 Great Lakes Water Quality Agreement) all use *E. coli* (*E.*) measurements as an indicator of recreational water contact safety (Bushon and Koltun 2004, Brady and Plona 2010, Cuyahoga River Restoration 2018).

4.6.2. Data and Methods

Aquatic Life Use (IBI, MIwb, ICI)

Appendix C of the Cuyahoga River Area of Concern Stage 2 Delisting Implementation Plan (Cuyahoga River Restoration 2015) lists IBI, MIwb, and ICI data for each watershed in the Cuyahoga River Area of Concern (AOC) for all samples taken from 2006 to 2013, and whether or not they meet delisting criteria. The 2006 to 2013 data will be used to determine a current condition rating. To determine the current rating, each bioindicator will be given a condition rating of "Good" (green), moderately impaired or "Moderate" (yellow), or severely impaired or "Poor" (red) by taking all samples for that watershed and scoring them using the point system described in section 3.2.3. The overall score for each bioindicator will then be calculated from the individual watershed scores using the same scoring method (good condition = 100, moderately impaired = 50, and poor condition = 0). Available data from 2005 and earlier will be used as a historical reference to determine a trend for each indicator. Historical data come from a 2009 Cuyahoga River Remedial Action Plan (RAP) delisting request (CRRAPCC 2009), and Ohio EPA Technical Support Documents (TSD) from 1994 and 1999 (OEPA 1994 and OEPA 1999, respectively).

The study area consists of an upstream buffer of two miles from the mainstem Cuyahoga River for all tributaries, and a one mile downstream buffer on the mainstem Cuyahoga River as it exits CUVA

(Figure 4.6-2). This same study area was used by the NPS for the CUVA Baseline Water Quality Data report (NPS 1995).

<u>Coliform Bacteria (*E.coli*)</u>

Two studies conducted by the USGS and CUVA (Bushon and Koltun 2004, Brady and Plona 2009) examined *Escherichia coli* (*E.coli*) and other bacterial contaminants in the Cuyahoga River. These studies provided historical data for this measure, while data downloaded from STORET for 2015 and from Ohio NowCast for 2018 was used to assess the current condition in relation to recreational contact for the Cuyahoga River within CUVA.

In studies conducted on another large river, the Yampa River in Dinosaur National Monument, the USGS used a two-category scheme to assess the condition of recreational water quality via *E.coli*. These categories were Low Concern (the geometric mean is less than the standard), and High Concern (the geometric mean is more) than the standard (USGS 2017). These categories will be used in this assessment and will correspond to the severely impaired (poor condition, red) rating and good condition (green) categories. There is not a “moderately impaired” category for this measure.

A total of three water quality stations were used for this analysis, all within the CUVA boundary. Lock 29 (USGS-411433081330000, just downstream from Peninsula on the Ohio and Erie Canal Towpath Trail near Lock 29), Jaite (USGS-411747081341300, located within CUVA at Vaughn Rd. in Brecksville, OH), and Independence (USGS-0420800, at the downstream boundary of CUVA at Old Rockside Road in Independence, OH) are used because they are located within the boundaries of CUVA and are the only three sampling locations that had geometric mean data for at least one sampling year (2000/2002, 2015, or 2018). The data from Brady and Plona 2009 (2008 sampling) did not have geometric mean data and are not used to determine a statistical trend, but were included in the data summary to show an overall picture of recreational water quality between the 2000/2002 and 2015 sampling years.

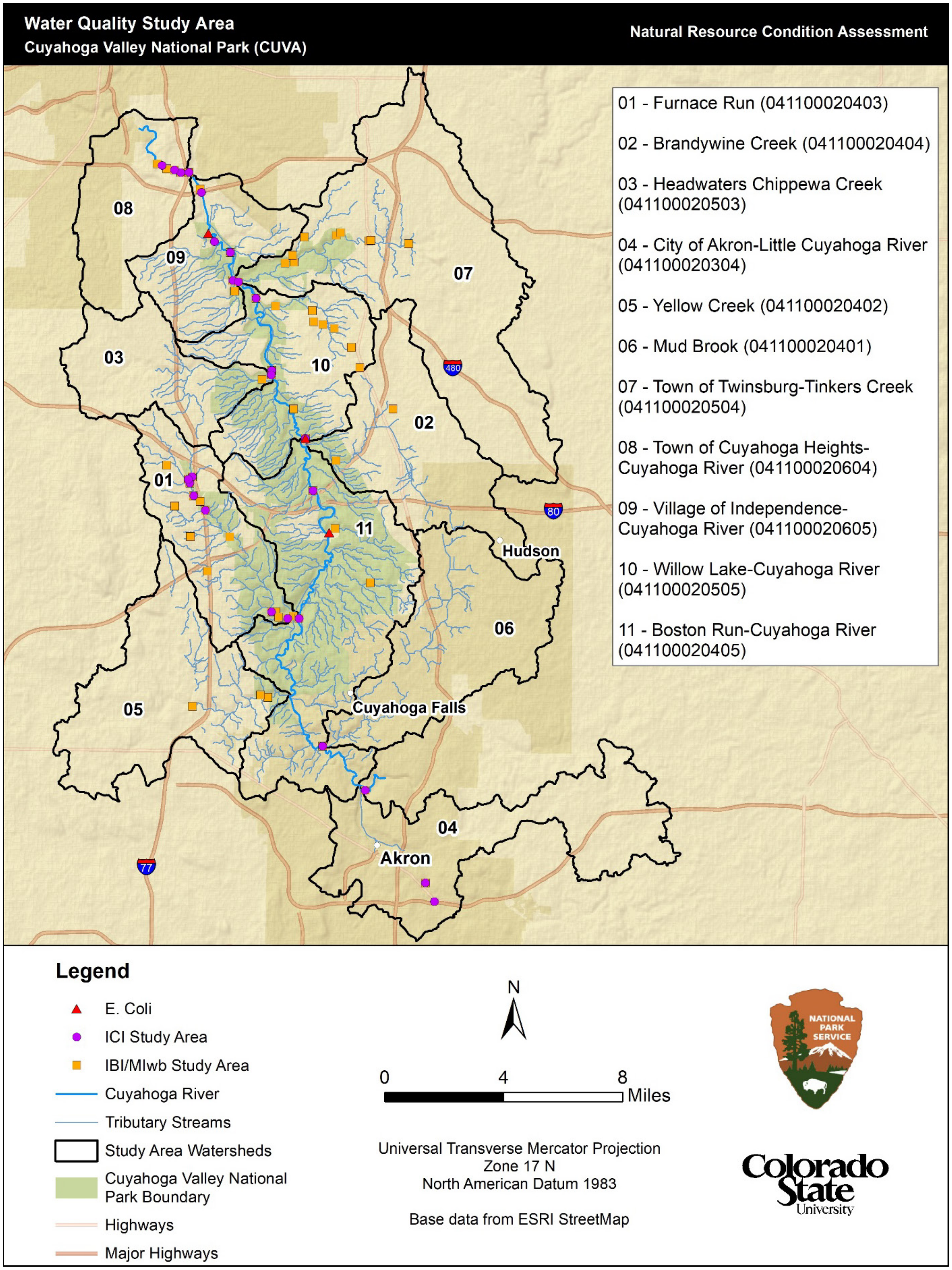


Figure 4.6-2. CUVA water quality study area and sampling locations (base data from ESRI Streetmap).

4.6.3. Reference Conditions

Aquatic Life Use (IBI, MIwb and ICI)

Reference conditions are based on either OEPA or EPA standards for each indicator/measure. A summary of reference conditions for WWH water quality indicators is shown in Table 4.6-2.

Table 4.6-2. Water quality standards for IBI, MIwb, and ICI for WWH (Cuyahoga River Restoration 2015).

Water Quality Indicator	Category	OEPA standard for WWH
Index of Biological Integrity (IBI)	Headwaters	40
	Wading	38
	Boat	40
Modified Index of well-being (MIwb)	Wading	7.9
	Boat	8.7
Invertebrate Community Index (ICI)	–	34

Coliform Bacteria (*E.coli*)

Reference Conditions are based on EPA standards for primary recreational contact and the OEPA BAV advisory level (Table 4.6-3). OEPA standards for primary contact state that the acceptable level of total coliforms is less than or equal to 126 Colony Forming Units (CFU) per 100 ml (OEPA 2016). Since 2016, the state of Ohio and CUVA have been using the Beach Action Value (BAV) for the purpose of issuing beach and bathing water advisories in the Cuyahoga River via NowCast, a website that is used to notify the public of these advisories (pers. communication Meg Plona, 2018). The BAV is considered to be a more protective measure in regards to public health (USGS 2018). For more on the development and theory behind the BAV, see EPA (2014).

Table 4.6-3. Water quality standard for primary recreational contact (OEPA 2016).

Indicator	Standard	Measurement Type
E. coli	126 colonies/100ml (Primary Recreational Contact)	Geometric Mean
	235 colonies/100ml (Beach Action Value)	Single Sample

4.6.4. Condition and Trend

Aquatic Life Use (IBI, MIwb, and ICI)

Index of Biological Integrity (IBI)

The mean IBI for the entire study area was 38, with a condition rating of moderately impaired (Table 4.6-2). Mean IBI for historical data was also in the moderately impaired category, although the historical data was at the bottom of the range (35) and the current data was toward the high end of the range (63) indicating substantial improvement although this was not captured due to the partitioning of the rating system. A Mann-Kendall non-parametric trend test indicates a significant improving trend in the data for IBI from 1984 to 2013 ($n = 134$, $\tau = 0.3117$, $p < 0.0001$, $\alpha = 0.1$).

Mean IBI for data collected from 2006 to 2013 by watershed ranged from 29 (Tinker's Creek) to 46 (Furnace Run) (Table 4.6-4). Boston Run, Headwaters Chippewa Creek, and Tinker's Creek all had substantial improvement in this metric between historical and current data. A Spearman's rank correlation coefficient test to examine the relationship between IBI and watershed position (upstream to downstream along the mainstem Cuyahoga River) indicates that IBI gets lower (more impaired) going from upstream to downstream ($n = 134$, $\rho = -.3496$, $p < 0.01$, $\alpha = 0.1$) (Figure 4.6-3).

Based on the available data, the IBI warrants moderate concern with an improving trend, with medium confidence in the assessment (Figure 4.6-4).

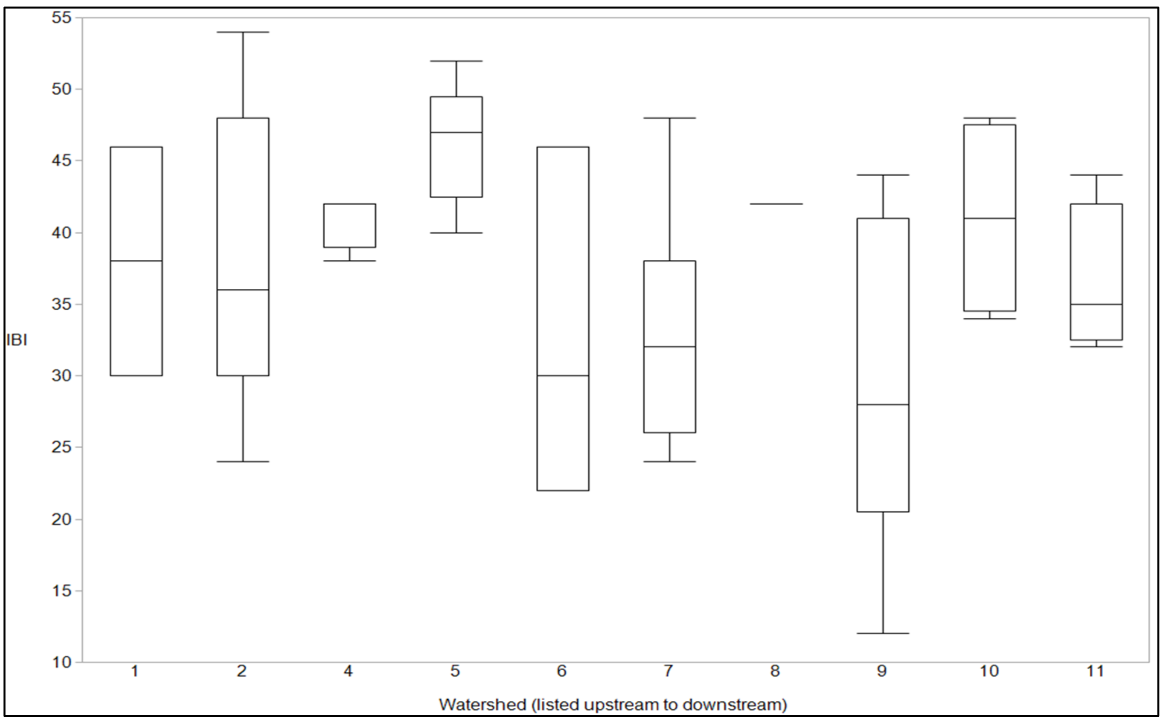


Figure 4.6-3. Boxplot of IBI calculations by watershed (listed upstream to downstream) within the CUVA study area from 2006 to 2013 (Cuyahoga River Restoration 2015). Watersheds are numbered as follows: 1. City of Akron – Little Cuyahoga River (041100020304); 2. Boston Run – Cuyahoga River (041100020405); 4. Yellow Creek (041100020402); 5. Furnace Run (041100020403); 6. Brandywine Creek (041100020404); 7. Willow Lake – Cuyahoga River (041100020505); 8. Headwaters Chippewa Creek (041100020503); 9. Town of Twinsburg – Tinker's Creek (041100020504); 10. Village of Independence – Cuyahoga River (041100020602); 11. Town of Cuyahoga Heights – Cuyahoga River (041100020604).

Table 4.6-4. Current IBI calculations (2006–2013) and historic condition rating (2005 and earlier) for watersheds, within the CUVA study area (Cuyahoga River Restoration 2015). Watersheds listed upstream to downstream.

Watershed (HUC)	Period of record	# obs[a]	# meets delisting criteria	# not in attainment	Max	Mean	Min	Current Condition Score	Current Condition Rating	Historic Condition Score	Historic Condition Rating
All	1984–2013	62	39	23	54	38	12	63	Moderate	35	Moderate
City of Akron – Little Cuyahoga River (041100020304)	1984–2010	2	1	1	46	30	38	50	Moderate	21	Poor
Boston Run – Cuyahoga River (041100020405)	1984–2011	5	4	1	54	38	24	80	Good	14	Poor
Mud Brook (041100020401)	No Samples	–	–	–	–	–	–	–	–	–	–
Yellow Creek (041100020402)	1984–2010	4	4	0	42	41	38	100	Good	91	Good
Furnace Run (041100020403)	1984–2012	16	16	0	52	46	40	100	Good	100	Good
Brandywine Creek (041100020404)	1984–2010	3	1	2	46	33	22	50	Poor	33	Poor
Willow Lake – Cuyahoga River (041100020505)	1984–2013	11	2	9	48	33	24	18	Poor	0	Poor
Headwaters Chippewa Creek (041100020503)	1996–2009	1	1	0	42	42	42	100	Good	33	Poor
Town of Twinsburg – Tinker's Creek (041100020504)	1984–2011	12	5	7	44	29	12	42	Moderate	0	Poor
Village of Independence – Cuyahoga River (041100020602)	1984–2012	4	3	1	48	41	34	75	Good	17	Poor
Town of Cuyahoga Heights – Cuyahoga River (041100020604)	1991–2012	4	2	2	44	37	32	50	Moderate	0	Poor

[a] # obs = number of observations for current data (2006 to 2013).

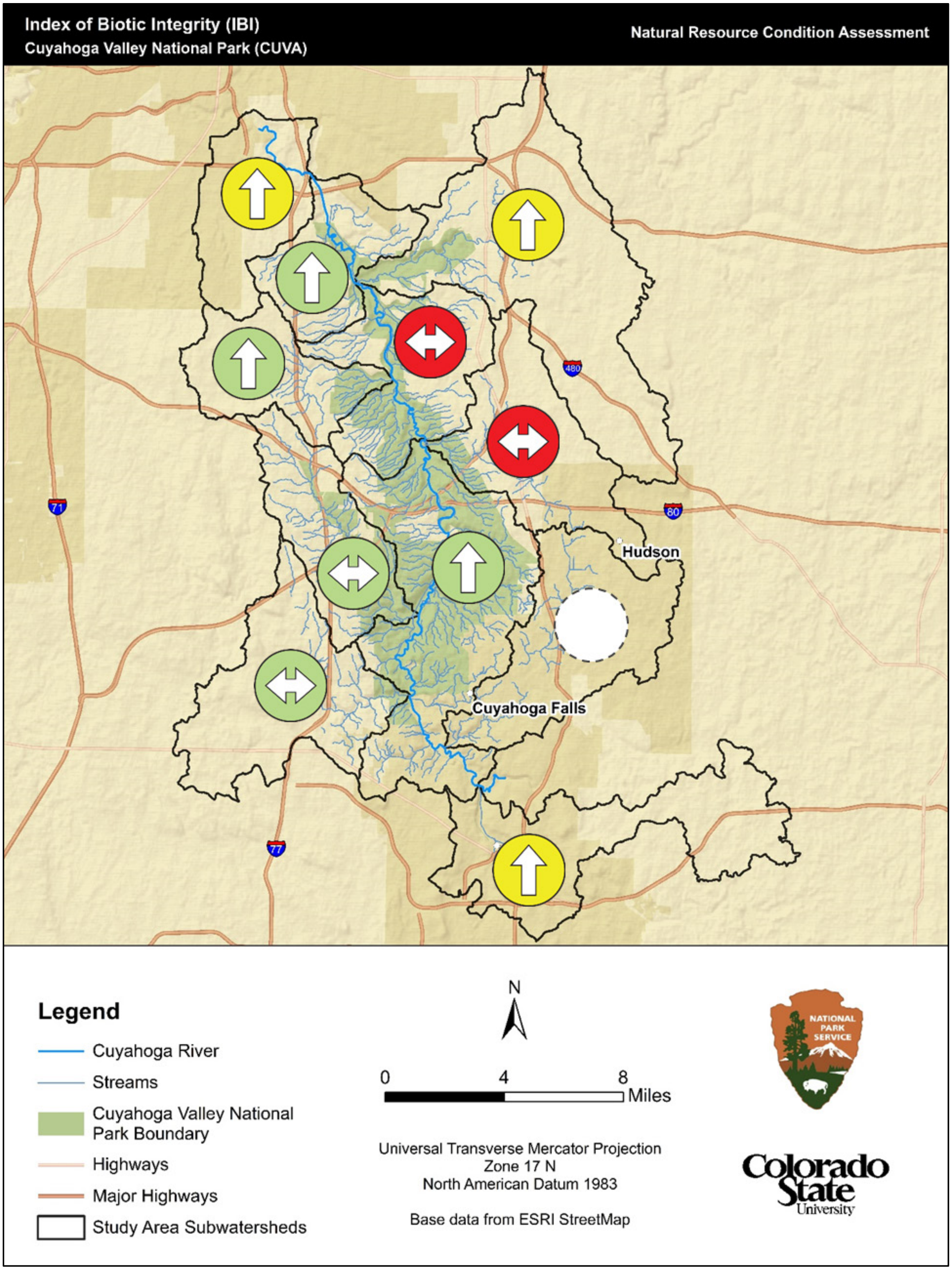


Figure 4.6-4. IBI ratings for CUVA watersheds (base data from ESRI Streetmap).

Modified Index of well-being (MIwb)

The mean MIwb for the entire study area was 7.9, with a condition rating of moderately impaired (Table 4.6-5). Mean MIwb for historical data was in the poor condition category, indicating substantial improvement in the overall study area. A Mann-Kendall non-parametric trend test indicates a significant improving trend in condition scores for MIwb from 1984 to 2013 ($n = 88$, $\tau = 0.4520$, $p < 0.0001$, $\alpha = 0.1$).

Mean MIwb for data collected from 2006 to 2013 by watershed ranged from 7.1 (Brandywine Creek) to 9.6 (Village of Independence – Cuyahoga River) (Figure 4.6-5). All watersheds with the exception of Yellow Creek and Brandywine Creek (Furnace Run was already in the good condition category for historical data, and had only a single data point) had substantial improvement in this metric between historical and current data. A Spearman's rank correlation coefficient test that tested for a relationship between MIwb and watershed position (upstream to downstream along the mainstem Cuyahoga River) suggests that MIwb gets higher (less impaired) going from upstream to downstream ($n = 88$, $\rho = 0.3363$, $p < 0.05$, $\alpha = 0.1$).

Based on the available data, MIwb warrants moderate concern with an improving trend and medium confidence in the assessment (Figure 4.6-6).

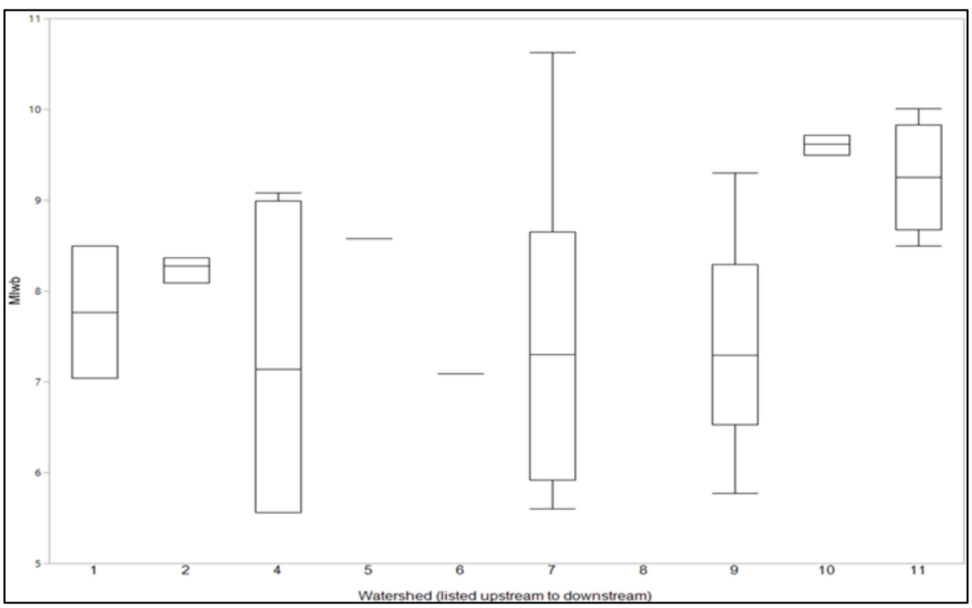


Figure 4.6-5. Boxplot of MIwb calculations by watershed (listed upstream to downstream) within the CUVA study area from 2006 to 2013 (Cuyahoga River Restoration 2015). Watersheds are numbered as follows: 1. City of Akron – Little Cuyahoga River (041100020304); 2. Boston Run – Cuyahoga River (041100020405); 4. Yellow Creek (041100020402); 5. Furnace Run (041100020403); 6. Brandywine Creek (041100020404); 7. Willow Lake – Cuyahoga River (041100020505); 8. Headwaters Chippewa Creek (041100020503); 9. Town of Twinsburg – Tinker's Creek (041100020504); 10. Village of Independence – Cuyahoga River (041100020602); 11. Town of Cuyahoga Heights – Cuyahoga River (041100020604).

Table 4.6-5. Current MIwb calculations (2006–2013) and historic condition rating (2005 and earlier) for watersheds, within the CUVA study area (Cuyahoga River Restoration 2015). Watersheds listed upstream to downstream. ND = No Data.

Watershed (HUC)	Period of record	# obs[a]	# meets delisting criteria	# not in attainment	Max	Mean	Min	Current Condition Score	Current Condition Rating	Historic Condition Score	Historic Condition Rating
All	2006–2013	37	22	15	10.6	7.9	5.6	60	Moderate	12	Poor
City of Akron – Little Cuyahoga River (041100020304)	2008–2010	2	1	1	8.5	7.8	7.0	50	Moderate	21	Poor
Boston Run – Cuyahoga River (041100020405)	2008	3	2	1	8.4	8.3	8.1	67	Good	0	Poor
Mud Brook (041100020401)	No Samples	–	–	–	–	–	–	–	–	–	–
Yellow Creek (041100020402)	2006–2010	4	2	2	9.1	7.2	5.6	50	Moderate	50	Moderate
Furnace Run (041100020403)	2012	1	1	0	8.6	8.6	8.6	100	Good	100	Good
Brandywine Creek (041100020404)	2010	1	0	1	7.1	7.1	7.1	0	Poor	ND	–
Willow Lake – Cuyahoga River (041100020505)	2008	5	4	1	10.6	8.4	5.9	80	Good	0	Poor
Headwaters Chippewa Creek (041100020503)	No Samples	–	–	–	–	–	–	–	–	–	–
Town of Twinsburg – Tinker's Creek (041100020504)	2006–2011	8	4	4	9.3	7.3	5.8	50	Moderate	0	Poor
Village of Independence – Cuyahoga River (041100020602)	2008–2012	3	3	0	9.7	9.6	9.5	100	Good	17	Poor
Town of Cuyahoga Heights – Cuyahoga River (041100020604)	2008–2012	4	4	0	10.0	9.3	8.5	100	Good	0	Poor

[a] # obs = number of observations for current data (2006 to 2013)(Cuyahoga River Restoration 2015).

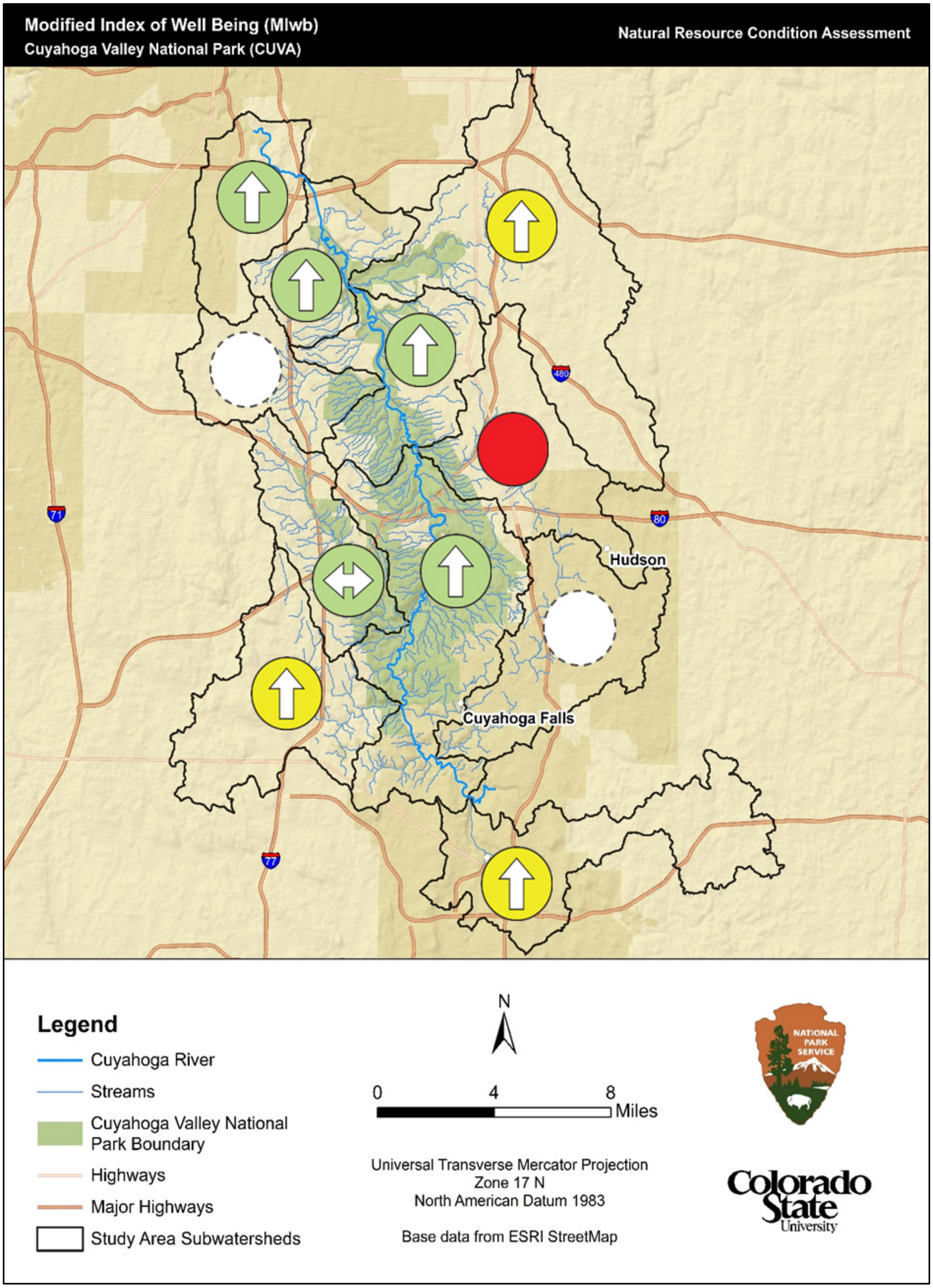


Figure 4.6-6. MIwb ratings of each of the eleven CUVA watersheds examined (base data from ESRI Streetmap).

Invertebrate Community Index (ICI)

The mean ICI for the entire study area was 40, with a good condition rating (Figure 4.6-7). Mean ICI for historical data was in the moderate condition category, indicating substantial improvement in the overall study area. A Mann-Kendall non-parametric trend test indicates a significant upward trend in the data for ICI from 1984 to 2013 ($n = 80$, $\tau = 0.4208$, $p < 0.0001$, $\alpha = 0.1$).

Mean ICI for data collected from 2006 to 2013 by watershed ranged from 36 (City of Akron – Little Cuyahoga River) to 45 (Willow Lake – Cuyahoga River) (Table 4.6-6). Tinker's Creek and Willow Lake – Cuyahoga River had substantial improvement in this metric between historical and current data. A Spearman's rank correlation coefficient test to test for a relationship between ICI and watershed position (upstream to downstream along the mainstem Cuyahoga River) suggests that there is no relationship between ICI and watershed position ($n = 26$, $\rho = 0.0459$, $p > 0.8$, $\alpha = 0.1$).Based on the available data, ICI is in good condition with an improving trend and medium confidence in the assessment (Figure 4.6-8).

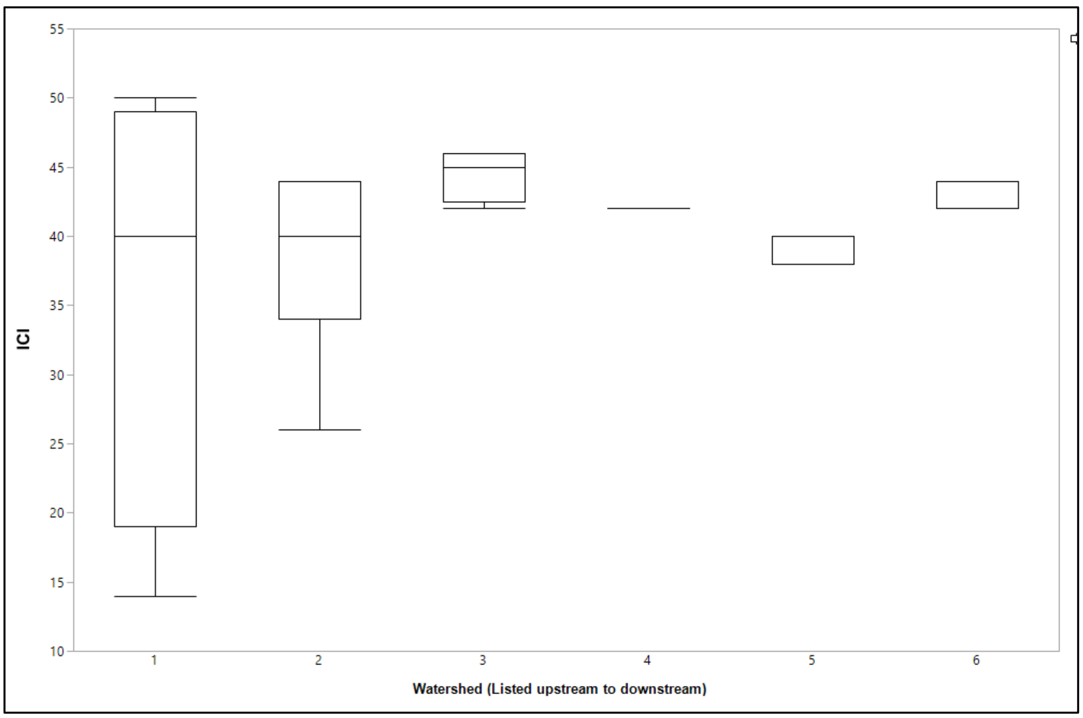


Figure 4.6-7. Boxplot of ICI calculations by Watershed (listed upstream to downstream) within the CUVA study area from 2006 to 2013 (Cuyahoga River Restoration 2015). Watersheds are numbered as follows: 1. City of Akron – Little Cuyahoga River (041100020304); 2. Furnace Run (041100020403); 3. Willow Lake – Cuyahoga River (041100020505); 4. Town of Twinsburg – Tinker's Creek (041100020504); 5. Village of Independence – Cuyahoga River (041100020602); 6. Town of Cuyahoga Heights – Cuyahoga River (041100020604).

Table 4.6-6. Current ICI calculations (2006–2013) and historic condition rating (2005 and earlier) for watersheds, within the CUVA study area (Cuyahoga River Restoration 2015). Watersheds listed upstream to downstream. ND = No Data.

Watershed (HUC)	Period of record	# obs[a]	# meets delisting criteria	# not in attainment	Max	Mean	Min	Current Condition Score	Current Condition Rating	Historic Condition Score	Historic Condition Rating
All	2006–2012	26	24	2	50	40	14	92	Good	59	Moderate
City of Akron – Little Cuyahoga River (041100020304)	2008–2010	4	3	1	50	36	14	75	Good	69	Good
Boston Run – Cuyahoga River (041100020405)	No Samples	–	–	–	–	–	–	–	–	46	Moderate
Mud Brook (041100020401)	No Samples	–	–	–	–	–	–	–	–	–	–
Yellow Creek (041100020402)	No Samples	–	–	–	–	–	–	–	–	91	Good
Furnace Run (041100020403)	2006–2009	7	6	1	44	38	26	86	Good	100	Good
Brandywine Creek (041100020404)	No Samples	–	–	–	–	–	–	–	–	40	Moderate
Willow Lake – Cuyahoga River (041100020505)	2008–2012	4	4	0	46	45	42	100	Good	57	Moderate
Headwaters Chippewa Creek (041100020503)	No Samples	–	–	–	–	–	–	–	–	–	–
Town of Twinsburg – Tinker's Creek (041100020504)	2008	1	1	0	42	42	42	100	Good	20	Poor
Village of Independence – Cuyahoga River (041100020602)	2008–2012	7	7	0	40	39	38	100	Good	86	Good
Town of Cuyahoga Heights – Cuyahoga River (041100020604)	2007–2008	3	3	0	44	43	42	100	Good	100	Good

[a] # obs = number of observations for current data (2006 to 2013)(Cuyahoga River Restoration 2015).

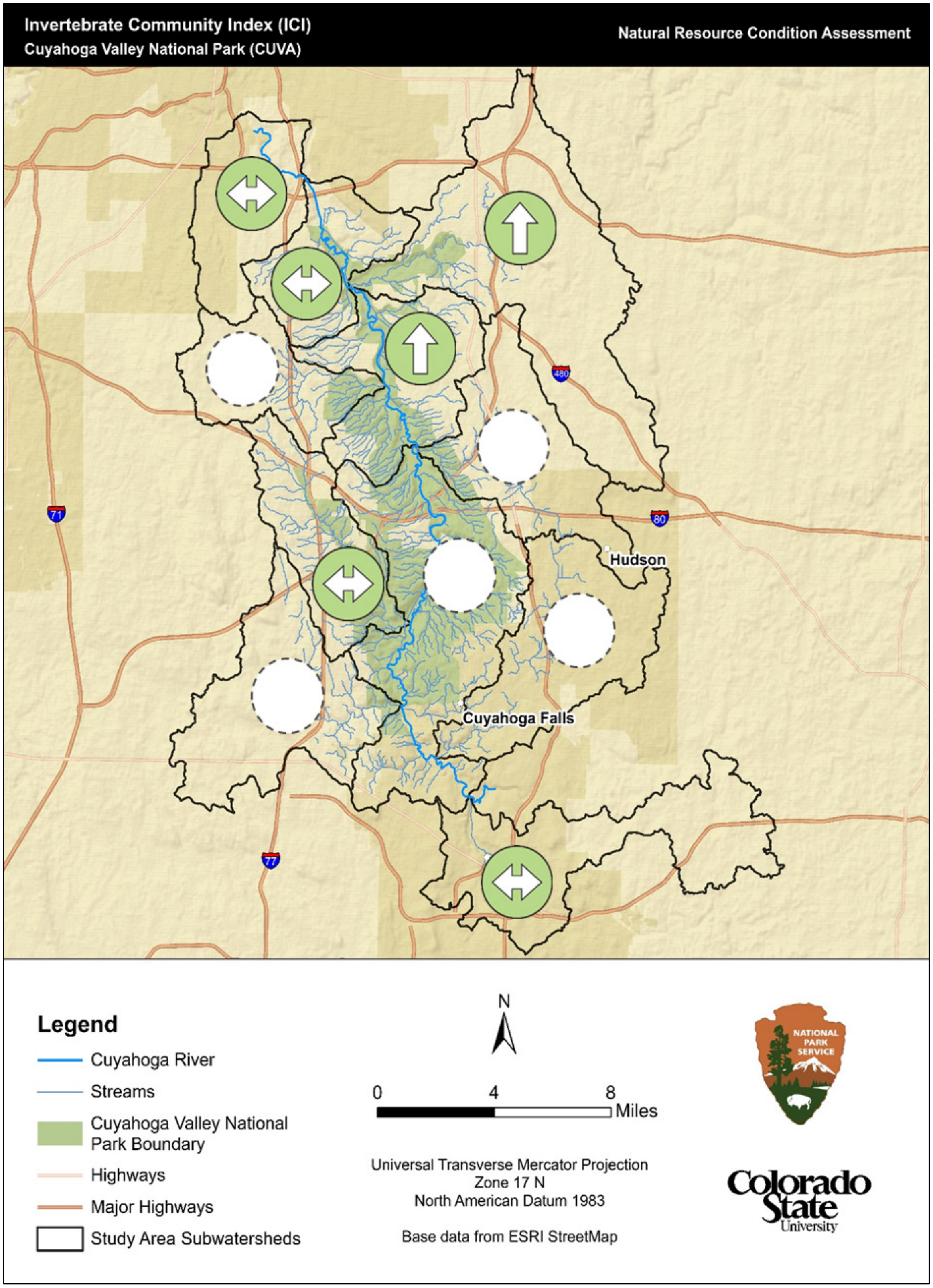


Figure 4.6-8. ICI ratings of each of the eleven watersheds used in this analysis (base data from ESRI Streetmap).

Coliform bacteria

USGS (Bushon and Koltun 2004, Brady and Plona 2009) and CUVA reviewed a total of 86 observations among the three study area monitoring stations within CUVA's boundary, 82 observations from the Lock 29 and Jaite locations in 2015 via STORET download, and 17 observations at Jaite in 2018 from NowCast (USGS 2018). The Independence sampling location did not have *E. coli* data later than 2011, and was not used for current condition. The mean and geometric mean value for all three of the stations (historical and current data) exceeded the EPA and BAV coliform standards (Table 4.6-7).

Table 4.6-7. Total coliform measurements from three monitoring stations including minimum, maximum, mean, median and geometric mean values (CFU/100 ml) (Bushon and Koltun 2004, Brady and Plona 2009, EPA 2018).

Station	Sampling Year	# obs	Max	Min	Mean	Median	Geometric Mean
Lock 29	2000/2002	–	–	–	–	–	–
	2008	8	930	77	430	330	–
	2015	52	110,000	120	7,789	830	1,306
Jaite	2000/2002	19	22,000	160	–	710	898
	2008	31	34,000	51	2,900	390	–
	2015	30	98,000	76	7,617	585	1,090
	2018	17	5,600	90	1,323	870	780
Independence	2000/2002	15	25,000	210	–	620	**975**[a]
	2008	13	800	78	290	200	**–**[a]
	2015	–	–	–	–	–	**–**[a]

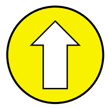
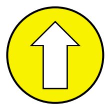
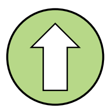
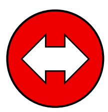
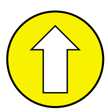
[a] Values used to assess condition and trend (geometric mean), also shown in bold text.

Based on the available data and the impairment of the Cuyahoga River by *E.coli*, the condition of recreational use at CUVA warrants significant concern with medium confidence due to the lack of data over time available from identical sampling points. No trend was assigned due to low confidence of in the data.

Condition Summary

The current condition of water quality in CUVA warrants moderate concern due to the impairments of *E. coli* for recreational use and mixed results for aquatic life use (Table 4.6-8). Assessing the current condition and trend of water quality is challenging due to the age of most monitoring data and numerous agencies collecting data around and within CUVA using different study designs and collection standards. Recent efforts by CUVA and OEPA to collect water quality data more frequently will improve the quality of future assessments, especially for recreational contact and *E. coli*. Although the status of water quality at CUVA and in the region is still impaired, efforts by the park and other public and private entities have greatly improved the well-being of the Cuyahoga River and its tributaries since the 1960s.

Table 4.6-8. Condition and trend summary for water quality for Cuyahoga Valley National Park.

Indicator	Condition Status/Trend	Rationale
Index of Biotic Integrity (IBI)		IBI is in moderate condition with an improving trend and medium confidence. Boston Run, Headwaters Chippewa Creek, and Tinker's Creek all had substantial improvement in this metric between historical and current data.
Modified Index of well-being (MIwb)		MIwb is in moderate condition with an improving trend and medium confidence in the assessment. All watersheds with the exception of Yellow Creek and Brandywine Creek had substantial improvement in this metric between historical and current data.
Invertebrate Community Index (ICI)		ICI is in good condition with an improving trend and medium confidence in the assessment. Tinker's Creek and Willow Lake – Cuyahoga River had substantial improvement in this metric between historical and current data, although adequate data was missing for five out of the 11 watersheds.
Primary Contact Recreation (*E. coli*)		Based on the available data and the impairment of the Cuyahoga River by *E.coli*, the condition of recreational use at CUVA warrants significant concern with no discernable trend. Confidence in the assessment is medium. Continued use of the NowCast system will most likely show an improvement in condition of this measure in the near future.
Water Quality overall		Overall water quality condition warrants moderate concern, the trend is improving, and confidence is medium.

4.6.5. Uncertainties and Data Gaps

Additional sampling of CWH streams should be implemented to determine their status over time. Collaboration with other public and private entities to standardize water quality sampling efforts will allow more robust analyses to be conducted in the future.

4.6.6. Sources of expertise

- Meg B. Plona, Biologist, CUVA

4.6.7. Literature cited

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4.7. Forests

4.7.1. Background and Importance

The Eastern Deciduous Forest ecosystem once covered almost a million square miles of the eastern United States stretching from the Atlantic seaboard west to the eastern portions of Minnesota, Iowa, Illinois, Missouri, Texas, and Oklahoma (Delcourt and Delcourt 2000). Stretching across 26 states, including all of Ohio, this ecoregion exhibited vast stretches of unbroken forest which persisted for thousands of years (NPS 2016). Eastern Ohio is part of the Allegheny Plateau physiographic section that is subdivided into southern and northern glaciated regions. Cuyahoga Valley National Park (CUVA) lies within this glaciated region in northeastern Ohio and is part of the Erie Drift Plain Level III ecoregion (Figure 4.7-1) (Omernik 1987). CUVA includes 33,000 acres of land along 22 miles of the Cuyahoga River between the cities of Cleveland and Akron, Ohio.

Forest community at CUVA (CSU Photo/D. Jones).

Ohio, like much of the eastern U.S., has been heavily impacted from changes resulting from urbanization and forest clearing (Day 1953, MacCleery 1994). Presettlement, nearly all of Ohio was covered by old-growth forests. After Euro-American settlement, forest cover across the state was reduced to the point that only 10% of the state was forested by the early 1900s. Today, the state's forest cover has increased to about 31% (including tree plantations) with many of the forests being highly fragmented and occurring predominantly on private lands—86% of Ohio forests are private owned (Widmann et al. 2014). Old-growth stands now account for less than one percent of the statewide forest cover and virgin forests are considered to be extirpated from the state (OEC 2015). Although forests are no longer the dominant feature on Ohio's landscape, existing forests still provide an important array of essential ecological and agricultural benefits to the state. Wildlife habitat, temperature control, biodiversity, water quality protection, wetland protection, flood attenuation, and a variety of cultural, agricultural, and recreational uses are important benefits provided by Ohio's forests. Forest resources at CUVA exemplify all of these benefits and represent one of the best forest resources for the entire state (NPS 2013).

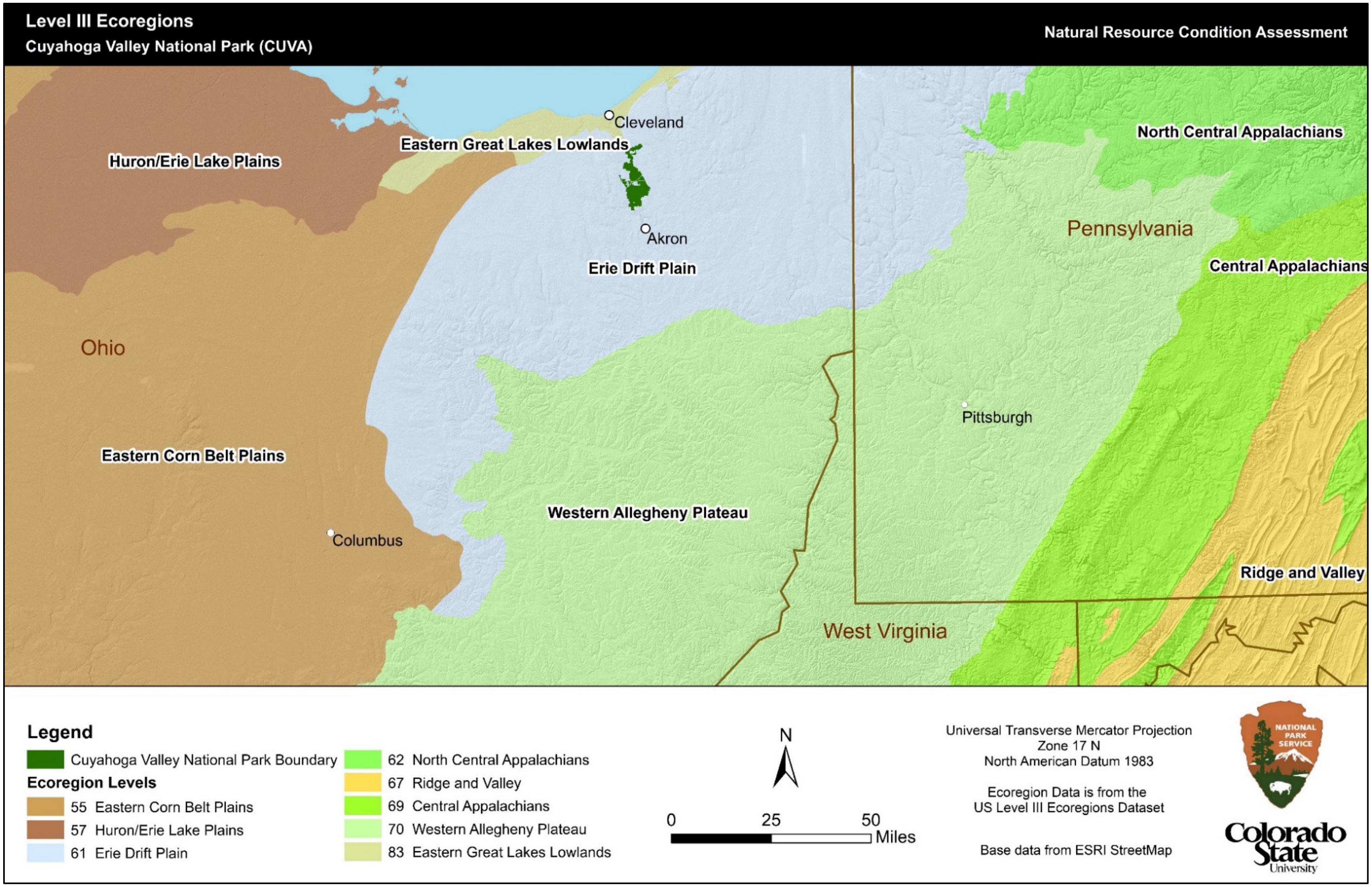


Figure 4.7-1. CUVA lies within the Erie Drift Plain Level III Ecoregion on the glaciated portion of the Allegheny Plateau in northeastern Ohio (Omernik 1987).

At CUVA, secondary forests are developing across much of the landscape—reflecting a diverse land use history which has included intensive agriculture use, timber harvest, and urban development. The park contains some of the largest remaining forest tracts in northeast Ohio, helping to support biodiversity as well as provide corridors for migratory wildlife species (NPS 2013). Forests at CUVA include successional and older growth forests intermixed with wetlands and bottomland forests, providing park visitors a chance to experience a wide array of plants and animals (NPS 2017a).

The Eastern Deciduous Forest canopy of today is typically dominated by oaks (*Quercus* spp.), hickories (*Carya* spp.), tulip poplar (*Liriodendron tulipifera*), American beech (*Fagus grandifolia*), maples (*Acer* spp.), and basswood (*Tilia americana*). Typical canopy species of bottomland forests include red maple (*A. rubrum*), American elm (*Ulmus americana*), and swamp white oak (*Q. bicolor*) (Goebel et al. 2003).

Forest resources at CUVA have been influenced by historical land uses that have changed the species composition and age structure of the forest. Although large tracts of forests can be found within the park, the majority of the forested areas are fragmented with few old growth stands remaining. In addition, the surrounding land use include areas of intense urban development which impacts the forest ecosystem. As local populations have increased, so has the suppression of the natural fire regime leading to changes in forest species composition. In the past, in drier oak-hickory-dominated sites, periodic, low-intensity fires maintained the understory vegetation, naturally thinned the canopy density, and limited fire intolerant species from entering or dominating the canopy. As a result of fire suppression, fire-intolerant species such as maples and beeches have increased in dominance, which has altered and displaced original forest communities (NPS 2017a).

The structure of the original forests at CUVA would likely have included trees in excess of 300 years old with a mixed-age canopy creating a mosaic of tree sizes and ages. Tree densities would have been distributed among all size classes and would have included trees with diameters greater than 70 cm. In addition, large volumes of coarse woody debris would be in various states of decay providing nutrient cycling on the forest floor and standing-dead snags would be present within the canopy providing critical wildlife habitat (Zawadzkas and Abrahamson 2003). The original forests likely had a greater number of canopy gaps compared to the forests we see today. Hix et al. (2011) found an old-growth beech-maple stand had 9.3% of the forest in canopy gaps while 3.7% of a nearby second-growth beech-maple stand was in canopy gaps.

As outlined in Hop et al. (2013), forest communities at CUVA are dominated by hardwood trees such as northern red oak (*Quercus rubra*), white oak (*Q. alba*), black oak (*Q. velutina*), chinquapin oak (*Q. muehlenbergii*), hickory species (*Carya* spp.), sugar maple (*A. saccharum*), and American beech (*Fagus grandifolia*). Red maple (*A. rubrum*), black cherry (*Prunus serotina*), tuliptree (*Liriodendron tulipifera*), and aspen species (*Populus* spp.) characterize the early-successional forests. Hop et al. (2013) found conifer forests to be much less common than hardwood forests, with eastern hemlock (*Tsuga canadensis*)-mixed hardwood forests being largely restricted to the “Ledges” area of the park. Additionally, a number of planted conifer forests are also checkered across the landscape of the park (Hop et al. 2013). Riparian floodplain and bottomland forests consist largely of silver maple (*A. saccharinum*), eastern cottonwood (*P. deltoides*), American sycamore (*Platanus occidentalis*), black walnut (*Juglans nigra*), green ash (*Fraxinus pennsylvanica*), common hackberry (*Celtis occidentalis*), red maple, and tuliptree. Rare occurrences of black ash (*F. nigra*) and swamp white oak (*Q. bicolor*) can also be found in some bottomland forest settings (Hop et al. 2013).

The vegetation inventory and mapping project at CUVA (Hop et al. 2013) resulted in 29 map classes being mapped representing 44 natural or semi-natural vegetation associations from the United States National Vegetation Classification (USNVC). Of the 29 map classes, 15 represent forest or woodland communities (Table 4.7-1). Approximately 74.4% (~24,000 acres) of CUVA was mapped as forest with 42.6% (~10,000 acres) of the forest representing successional forest types and 57.4% (~14,000 acres) representing non-successional forest types (Figure 4.7-2) (Hop et al. 2013). Upland forest accounted for about 87% of the total CUVA forest and bottomland or riparian forest represented about 13% of the total forest (Figure 4.7-3) (Hop et al. 2013).

For this assessment, the condition of both upland and bottomland forest at CUVA was evaluated. Forest communities at CUVA have a long history of being impacted by a variety of stressors and threats including noxious and invasive weeds, diseases and insect pests, compounding effects of climate change, air pollution, acid rain/atmospheric chemistry, past land uses, and impacts associated with overabundant white-tail deer populations (NPS 2014, 2016). These stressors and threats have collectively shaped and continue to impact forest community condition and ecological succession.

Beginning in 2007, the NPS began a formal program of monitoring and managing invasive species at CUVA. Surveys in 2003, 2007 and 2016 at CUVA documented high levels of invasive exotic plants throughout the park (Vorac and Schramm 2003, Djuren and Young 2007, Morgan et al. 2018). Monitoring of the 2007 survey areas in 2016 provides trend data pertaining to invasive weed frequency and abundance across the park to identify priorities and evaluate management effectiveness (Morgan et al. 2018).

<u>Rare Plants and Plant Communities</u>

A number of rare plants and plant communities are contained within the park. Rare forest communities at CUVA include natural plant communities that are rare at the park, occupying less than 1% of the forested area and occurring at fewer than 10 locations, and/or are rare on a state or global scale. Six upland communities and three bottomland communities are considered to be rare at CUVA (Table 4.7-2). Two communities (Beech – Maple Glaciated and the Northern (Great Lakes) Flatwood Forests) are considered to be globally imperiled and state vulnerable (G2G3/S3) (NatureServe 2020). The Black Oak – White Oak / Blueberry Forest, Silver Maple – Elm Forest, and Central Appalachian Acidic Cove Forest are ranked as globally apparently secure, however, mature high quality stands are considered uncommon. The East-Central Hemlock-Hardwood Forest is ranked as globally vulnerable. One of the most common forests at CUVA, the Successional Mixed Hardwood Forest includes forests that are greater than 250 years old (Hop et al. 2013). The Successional Cottonwood Forest is considered to be uncommon at CUVA and includes the Terra Vista Natural Study Area.

Table 4.7-1. Extent of mapped upland and bottomland forest vegetation associations by map class and physiognomic category at CUVA (Hop et al. 2013).

Forest Type	Physiognomic Category	Mapped Class Name	Ecological Associations	Acres	Hectares
Upland Forests	Successional Hardwood Forest	Successional Black Locust Forest	*Robinia pseudoacacia* Semi-natural Forest	19.5	7.9
	Successional Hardwood Forest	Successional Mixed Hardwood Forest	Acer rubrum – Prunus serotina / Rosa multiflora Forest	8,639.3	3,496.2
	Successional Hardwood Forest	Successional Mixed Hardwood Forest	*Liriodendron tulipifera – Acer rubrum – Populus* spp. Forest	–	–
	Successional Hardwood Forest	Successional Cottonwood Forest	Successional *Populus* spp. Semi-natural Forest	76.6	31.0
	Oak – (Hardwood) Forest	Black Oak – White Oak / Blueberry Forest	*Quercus velutina – Quercus alba / Vaccinium (angustifolium, pallidum) / Carex pensylvanica* Forest	18.0	7.3
	Oak – (Hardwood) Forest	Dry-Mesic Oak Forest	*Quercus alba-Quercus rubra – Carya ovata* Glaciated Forest	7,631.3	3,088.3
	Oak – (Hardwood) Forest	Dry-Mesic Oak Forest	*Quercus velutina – Quercus alba – Carya (glabra, ovata)* Forest	–	–
	Oak – (Hardwood) Forest	Sugar Maple – Chinkapin Oak Forest	*Acer saccharum – Quercus muhlenbergii* Forest	24.5	9.9
	Northern Hardwood Forest	Beech – Maple Glaciated Forest	*Fagus grandifolia – Acer saccharum* Glaciated Midwest Forest	3,881.5	1,570.8
	Successional Conifer – (Hardwood) Forest	Successional Conifer Plantation Forest	*Larix laricina* Planted Forest *Picea abies* Planted Forest *Pinus strobus* Planted Forest *Pinus sylvestris* Planted Forest *Pinus virginiana* Planted Forest	936.0	378.8
	Successional Conifer – (Hardwood) Forest	Successional Conifer Plantation Forest	*Picea abies – Acer rubrum – Liriodendron tulipifera* Ruderal Forest	–	–
	Hemlock – Hardwood Forest	East-Central Hemlock – Hardwood Forest	*Tsuga canadensis – Fagus grandifolia – Acer saccharum / (Hamamelis virginiana, Kalmia latifolia)* Forest	70.9	28.7

Table 4.7-1 (continued). Extent of mapped upland and bottomland forest vegetation associations by map class and physiognomic category at CUVA (Hop et al. 2013).

Forest Type	Physiognomic Category	Mapped Class Name	Ecological Associations	Acres	Hectares
Upland Forest (cont.)	Hemlock – Oak Forest	Central Appalachian Acidic Cove Forest	*Liriodendron tulipifera – Pinus strobus – Tsuga canadensis – Quercus rubra / Polystichum arcrostichoides* Forest	6.7	2.7
	Total Upland	**–**	**–**	**21,304.3**	**8,621.5**
Bottomland Forests	Bottomland Hardwood Forest	Northern (Great Lakes) Flatwoods	*Quercus palustris – Quercus bicolor – Acer rubrum* Flatwoods Forest	25.5	10.3
	Bottomland Hardwood Forest	Red Maple – Black Ash Swamp	*Fraxinus nigra – Acer rubrum / Rhamnus alnifolia / Carex leptalea* Forest	2.0	0.8
	Riparian Hardwood Forest	Silver Maple – Elm Forest	*Acer saccharinum – Ulmus americana* Forest	28.2	11.4
	Riparian Hardwood Forest	Cottonwood – Sycamore Floodplain Hardwood Forest	*Platanus occidentalis – Juglans nigra – (Fraxinus americana)* Forest *Populus deltoides – Salix nigra* Forest	2,334.7	944.8
	Successional Bottomland – Riparian Hardwood Forest	Successional Floodplain Hardwood Forest	*Liriodendron tulipifera – Ulmus* spp. *– Fraxinus pennsylvanica* Forest *Fraxinus pennsylvanica – Ulmus* spp. *– Celtis occidentalis* Forest	740.8	299.8
	Total Bottomland	**–**	**–**	**3,131.2**	**1,267.2**

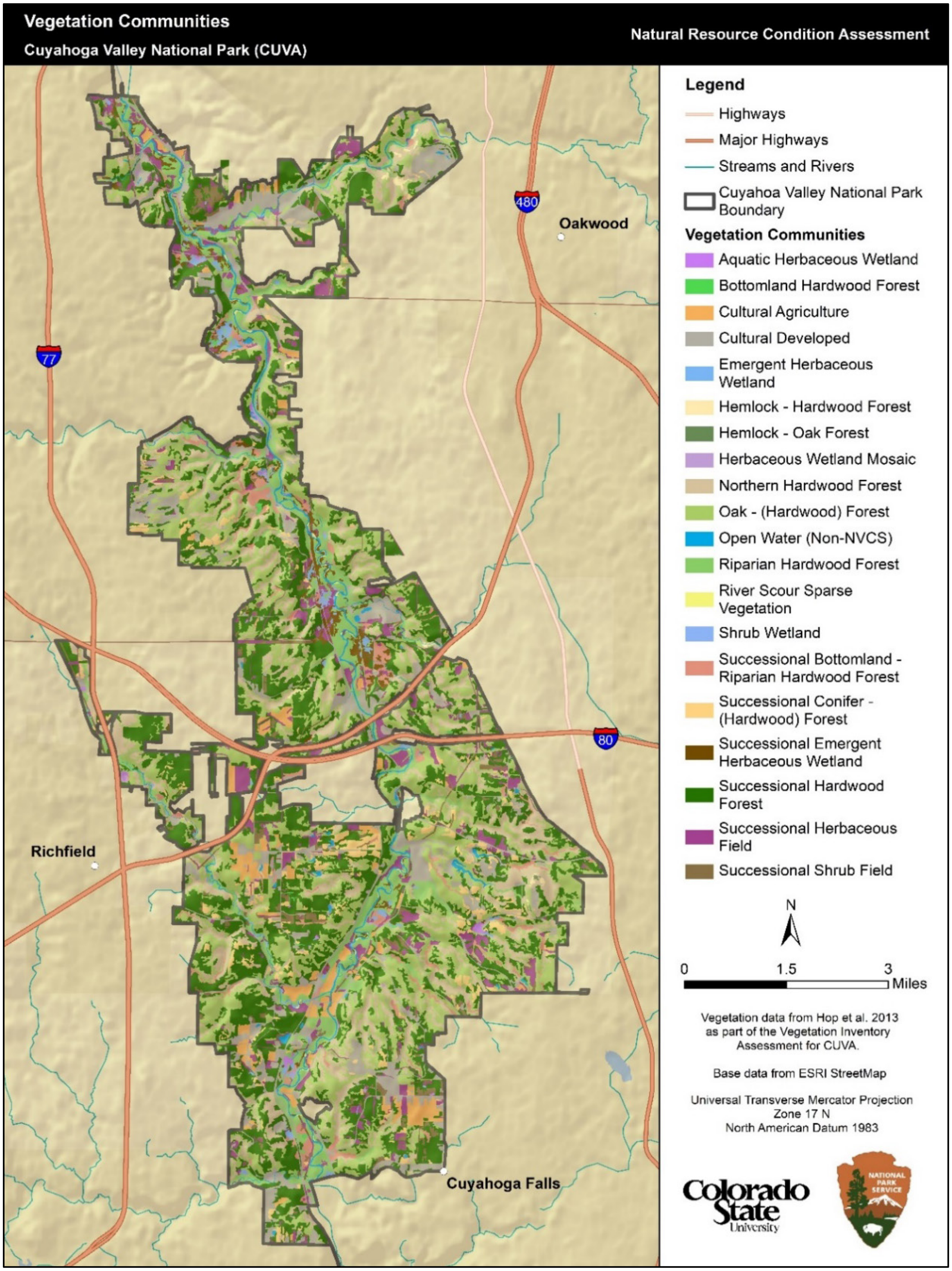


Figure 4.7-2. Vegetation community map for CUVA derived from data from the vegetation inventory project from Hop et al. (2013). Original map classes have been lumped into physiognomic categories.

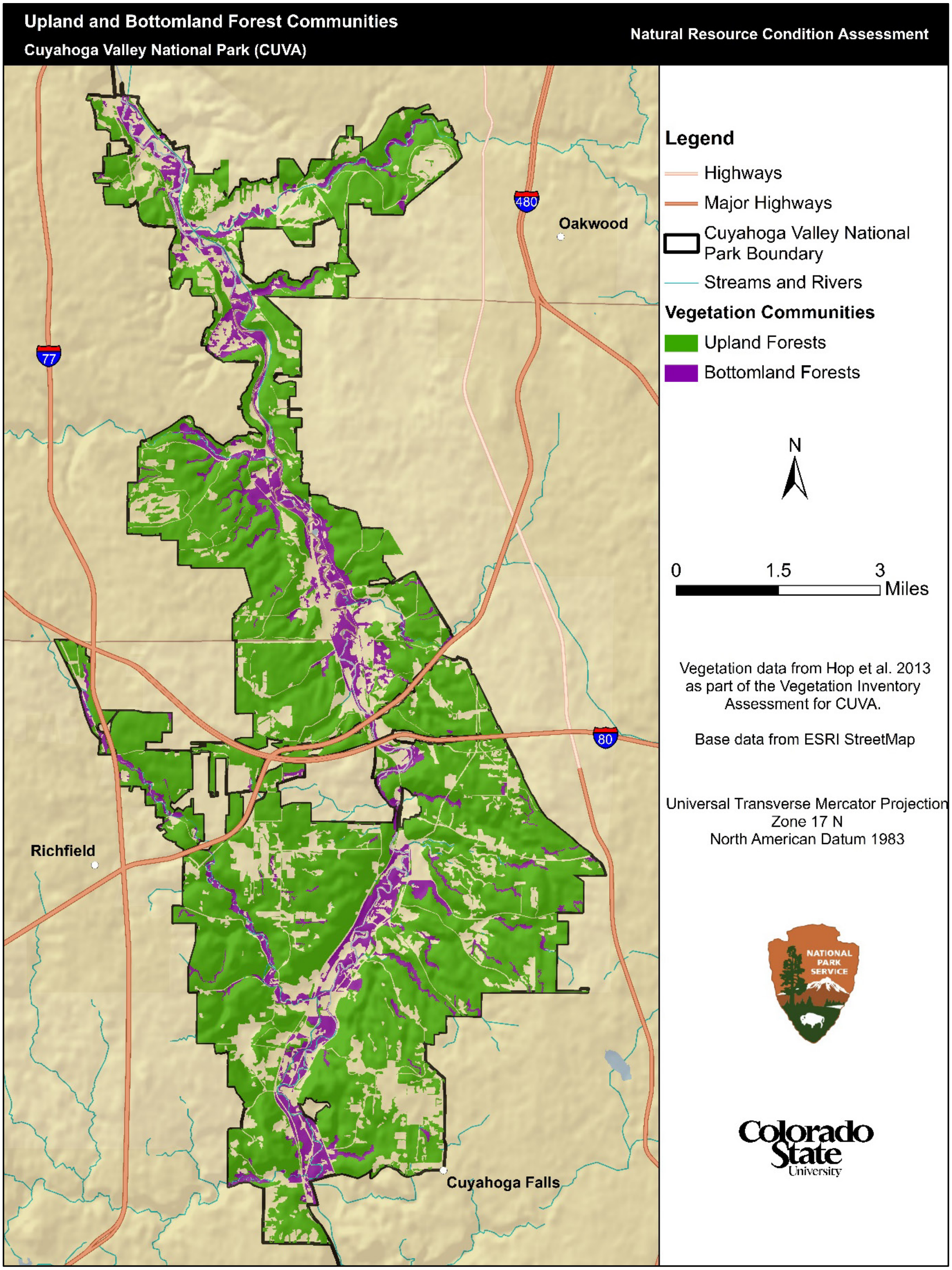


Figure 4.7-3. Upland and bottomland forest distribution at CUVA based on data from Hop et al. (2013).

Table 4.7-2. Rare and uncommon plant communities at CUVA (Hop et al. 2015) and their NatureServe conservation status rank (NatureServe 2020).

Forest Type	Forest Association	Mapped Locations (#)	Forest Cover %	NatureServe Conservation Status Rank
Upland Forests	Black Oak – White Oak / Blueberry Forest	1	0.07	G4 – apparently secure
	Sugar Maple – Chinkapin Oak Forest	2	0.10	no status rank assigned
	Central Appalachian Acidic Cove Forest (Kendall Ledges area)	3	0.02	G4 – apparently secure
	Beech – Maple Glaciated Midwest Forest	339	16.0	G2 – imperiled
	East – Central Hemlock – Hardwood Forest	17	0.30	G3 – vulnerable
	Successional Cottonwood Forest (Terra Vista Natural Study Area)	11	0.30	Uncommon
Bottomland Forests	Northern (Great Lakes) Flatwoods	9	0.10	G2 – imperiled, S2 – vulnerable
	Red Maple – Black Ash Swamp (rarest vegetation type at CUVA)	1	0.003	GNR – no status rank
	Silver Maple – Elm Forest	9	0.12	G4 – apparently secure

A total of ten rare species out of a total of 40 known rare species from CUVA were recorded in forest plots by Hop et al. (2013). Three rare plant taxa were observed in the Beech – Maple Glaciated Midwest Forest. Rare plants were also located in four other communities that are not considered rare including the following: Dry – Mesic Oak Forest (3 taxa); Successional Mixed Hardwood Forest (2 taxa); Cottonwood – Sycamore Floodplain Forest (2 taxa); and Successional Floodplain Hardwood forest (1 taxon) (Table 4.7-3).

Table 4.7-3. Rare plants documented by Hop et al. (2013) at CUVA in forest survey plots, and corresponding conservation status rank (NatureServe 2020) and Ohio DNR rare plant status (ODNR 2020).

Scientific Name	Common Name	Forest Map Class Name	NatureServe Conservation Status – Global / National / Subnational [a]	Rare Plant Status ODNR 2018–19
Actaea rubra	Red baneberry	Cottonwood – Sycamore Floodplain Hardwood Forest	G5/N5/S2	State threatened
Asclepias variegata	White milkweed	Successional Mixed Hardwood Forest	G5/S3	Potentially threatened
Castanea dentata	American chestnut	Dry-Mesic Oak Forest	G4/N4/S3	–
Gallium labradoricum	Northern bog bedstraw	Beech – Maple Glaciated Forest	G5/S1	State Endangered
Galium palustre	Common marsh bedstraw	Cottonwood – Sycamore Floodplain Hardwood Forest	G5/S1 (2001)	State threatened
Oligoneuron ohioense	Ohio goldenrod	Dry-Mesic Oak Forest	G4/N4/ S3	–
Ophioglossum engelmannii	Limestone adderstongue	Beech – Maple Glaciated Forest	G5/S2	State Endangered
Phaseolus polystachios	Thicketbean	Successional Floodplain Hardwood & Successional Mixed Hardwood Forest	G5/S2	Potentially threatened
Phegopteris connectilis	Long beechfern	the Beech – Maple Glaciated Forest	G5/S3	–
Viburnum opulus var. *americanum*	American cranberrybush	Dry-Mesic Oak Forest	G5T5/S2	State Endangered

[a] See NatureServe (2020) for rank definitions

Late-Successional and Old-Growth Forest

There is little true old-growth forest remaining in the Lake States and Northeast regions. Late-successional forest having some old growth characteristics is more abundant compared to the post-settlement agricultural era, but is disappearing in many forest landscapes as land is converted to other uses (Hagan and Whitman 2005). Some of the best remaining examples of old-growth forest in Ohio are in the State Nature Preserve system. Protected areas such as Goll Woods, Hueston Woods, Johnson Woods, Clear Fork Gorge and Davey Woods provide a primitive atmosphere. Tracts vary in size from scattered patches of less than 10 acres to larger, contiguous tracts up to several hundred acres in size. Stands include forest types such as oak-hickory, beech-maple, mixed mesophytic, swamp, floodplain, and coniferous types (ODNR 2017a). High-quality examples of old growth forests near CUVA include Crall Woods at Pine Hill Park and A.B. Williams Memorial Woods at

North Chagrin Reservation-Cleveland Metroparks. Protected areas within Ohio and surrounding states can provide important reference areas for evaluating and managing stands in CUVA.

Areas within CUVA exhibiting late successional or old-growth characteristics include Kendall Ledges and the Kendall Lake /Pine Hollow area, the west side of the Buckeye Trail west of the Boston Store Visitor Center, Brecksville Reservation (Cleveland Metroparks), and the areas near Brandywine Falls including notable ravine forests with eastern hemlock (pers. comm. M. Plona, August 2015). The Virginia Kendall Park area is probably the oldest forest area and contains some of the highest quality examples of forests and rare species (NPS 2013).

Despite the rarity of late successional and old-growth areas within the park, there has been no comprehensive inventory of the extent and quality of forests having distinctive characteristics that develop over hundreds of years. It is possible that areas within CUVA outside of known examples within Metroparks and other lands warrant additional protection or management. Lack of information regarding locations and conditions preclude including old growth and late successional forests as an indicator of forest condition at CUVA.

Threats and Stressors

Primary threats to forest ecosystems at CUVA include: 1) historical land uses that have impacted the age and forest community structure; 2) fragmentation from development and recreational uses that have reduced the continuity of the large tracts of forest; 3) impacts from surrounding intense urban development; 4) increases in human population have that led to increased suppression of natural fires, which has changed forest species composition; 5) overabundant white-tailed deer populations that impact forest community composition and structure (NPS 2014); and 6) non-native exotic weeds, pathogens, and insects that also influence forest composition (Fisichelli et al. 2014). Compounding the effects of these stressors and threats are impacts from climate change, air pollution, acid rain, and changes in atmospheric chemistry (NPS 2016).

Indicators and Measures

- Community composition (Native Species Composition)
- Invasive exotic plants (IEP % cover and IEP trends)
- Floristic Quality Assessment (*FQAI*) and Mean Coefficient of Conservatism
- Ohio Rapid Assessment Method (ORAM) Condition Ranking
- White-tail deer population and associated impacts
- Forest pests and diseases
- Forest vulnerability to climate change

4.7.2. Data and Methods

Species Composition and Diversity

The community structure, composition, condition, and diversity of the forests were evaluated primarily with data collected by Hop et al. (2013) during the vegetation inventory and mapping project at CUVA. The project used vegetation plot data, field reconnaissance and aerial imagery to describe and map vegetation communities across CUVA using the USNVC. A total of 221 vegetation plots were used to help classify and describe CUVA vegetation communities for the park. Information that was collected at each plot included vegetation structure and cover by stratum (herbaceous, shrub, or tree canopy), as well as percent cover for all plant species within a $400m^2$ plot. For this condition assessment, this data was used to evaluate the forest community structure, composition, diversity, richness, and to calculate an index of floristic quality that was used to evaluate forest condition as well as provide comparison information for reference conditions. Each vegetation map class represented at least one community type (association). Some map classes included more than one community type due to similarities in aerial photo-signatures, community descriptions, or for instances where communities existed as a complex that could not be mapped separately from one another. See Hop et al. (2013) for details on data collection and map accuracy. Average native species composition was determined by calculating the average number of native plant species documented in each plot within upland and bottomland forest communities at CUVA.

Invasive Exotic Plants

Non-native plant species are those considered to have been introduced by humans after the arrival of Euro-Americans in the region. While non-native plant species are typically indicative of some level of disturbance, these species vary widely in their potential to cause ecosystem harm. Most non-native plant species are not considered invasive. Invasive species are non-native species that are considered to invade natural habitats and cause some level of environmental or economic harm.

Primary data sources for examining invasive exotic plants are the vegetation classification and mapping plot data (Hop et al. 2013) and Heartland I&M Network invasives survey data collected in 2007 and 2016 and summarized by Morgan et al. (2018). Of the approximately 99 plants on the park's "watch list", sixteen species are considered to be the most invasive within the park (Djuren and Young 2007, NPS 2017b) (Table 4.7-4). These plants invade a broad range of habitats including forests, meadows, wetlands, and disturbed areas such as roadsides (NPS 2017b). For the vegetation classification data, percent IEP cover for each $400m^2$ vegetation classification plot was calculated by summing the percent canopy cover values for these species. A total of 171 forested plots (62 in bottomlands and 109 in uplands) distributed across CUVA were included in the analysis.

Additionally, results reported by Morgan et al. (2018) from 2007 and 2016 HTLN IEP surveys were used to evaluate trend. Species included were listed on three watch lists. Invasive exotic plants not known to occur in the park based on NPSpecies (the national NPS database for plant occurrence registration) constituted the early detection watch list (n = 36). Invasive exotic plants known to occur on the park based on NPSpecies constituted the park-established watch list (n = 62). A third watch list, the park-based watch list, included one additional species of park concern. The HTLN sampling design consisted of a systematic grid of 822 search units with associated transects. Three equidistant passes through each search unit were made along a 3 to 12m-wide belt transect and survey cells were not fully searched (Morgan et al. 2018). The area occupied by each IEP species on each sample unit was estimated as an area (m^2) recorded as a cover class. Observations were used to estimate a range of species coverage within the park. Invasive and nonnative plant data from the vegetation inventory project are also integrated into the Floristic Quality Assessment Index summaries.

Table 4.7-4. The 16 most invasive plant species (IEP) occurring in CUVA as determined by Djuren and Young (2007).

Common Name	Scientific Name	Habitat	Estimated Parkwide Coverage (acres) in 2007
Garlic mustard	*Alliaria petiolata*	Moist ravines, dry roadsides, forest edges and interiors, floodplains	17.9–345.1
Japanese barberry	*Berberis thunbergii*	Closed-canopy forests, open woodlands, wetlands, fields, and roadsides	3.8–122.9
Autumn olive	*Elaeagnus umbellata*	Grasslands, open fields, woodlands, and disturbed areas	4.2–81.6
Common privet	*Ligustrum vulgare*	Wetlands, forests, fields, and flood plains	5.6–142.8
Japanese honeysuckle	*Lonicera japonica*	Floodplains, forest edges, and fields	2.7–69.1
Amur honeysuckle	*Lonicera maackii*	Woodlands, abandoned fields, roadsides, and marsh edges	1.2–26.9
Morrow honeysuckle	*Lonicera morrowii*	Woodlands, abandoned fields, roadsides, and marsh edges	2.8–68.9
Tatarian honeysuckle	*Lonicera tatarica*	Woodlands, abandoned fields, roadsides, and marsh edges	2.0–46.3
Purple loosestrife	*Lythrum salicaria*	Wet meadows, river and stream banks, pond edges, and ditches	1.7–32.1
Reed canarygrass	*Phalaris arundinacea*	Wet meadows and swamps and along streams; may form monocultures	14.6–219.5
Common reed	*Phragmites australis*	Wetlands, often in disturbed areas	5.8–108.2
Japanese knotweed	*Polygonum cuspidatum*	Riverbanks, wetlands, waste places, and disturbed areas; mainly open areas	9.2–147.2
Glossy buckthorn	*Rhamnus frangula*	Woodlands, riparian woodlands, forest edges, old fields, and fens	–
European buckthorn	*Rhamnus cathartica*	Woodlands, riparian woodlands, forest edges, old fields, and fens	0.04–1.6
Multiflora rose	*Rosa multiflora*	Fields, forests, prairies, stream banks, and wetlands	20.4–436.5
Narrow-leaved cattail	*Typha angustifolia*	Marshes, wet meadows, ditches and along pond and lakeshores; often in disturbed areas	2.6–38.0

Floristic Quality Assessment Index (FQAI) and Coefficient of Conservatism

Floristic quality was examined using *FQAI* tools. The *FQAI* approach to assessing ecological communities is based on the concept of species conservatism, whereby "coefficients of conservatism" (*C values*) are assigned to all the species in a state following methods described by Swink and Wilhelm (1994) and Wilhelm and Masters (1995). These values are assigned to each floral taxon by a panel of experts for the state or region. *C* values range from 0 to 10 and represent the estimated probability that a plant is likely to occur in a landscape relatively unaltered from pre-Euro-American settlement conditions. High *C* values are assigned to species which are obligate to high-quality natural areas and cannot tolerate habitat degradation. Generally, *C* values of 0 are represented by non-native species (or those always found in disturbed settings) and values in between reflect the range of disturbances tolerated by species (Andreas et al. 2004, Lemly and Gilligan 2015) (Table 4.7-5). *C* values that have been assigned to taxa in the Ohio flora are published in Andreas et al. (2004). The proportion of conservative plants in a plant community provide a powerful and relatively straight forward assessment of the integrity of both biotic and abiotic processes and is indicative of the ecological integrity of a site (Wilhelm and Ladd 1988).

Table 4.7-5. Coefficients of conservatism (*C* values) descriptions used in the *FQA* for vascular plants.

C	**Description**
0	Wide range of ecological tolerances, non-native opportunistic invaders or native taxa that are often part of ruderal communities.
1–2	Widespread taxa that are not typical of a particular community.
3–5	Intermediate range of ecological tolerances that typify a stable phase of a native community and persist under some disturbance.
6–8	Narrow range of ecological tolerances that typify a stable or near "climax" community. Obligate to more natural areas and can sustain some habitat degradation.
9–10	Obligate to high quality or relatively unaltered natural systems with a narrow range of ecological tolerances that exhibit a high degree of fidelity.

Sources: Andreas et al. 2004, Lemly and Gilligan 2015

The most basic *FQA* index is a simple average of the *C* values for a given site, generally called the "Mean *C*" or "$\overline{C}$" which can be used as a stand-alone indicator of habitat quality. An *FQAI* was also calculated for the upland and bottomland forests at CUVA. The *FQAI* can be conceptualized as the weighted averaging of species richness, with the *C* value assigned to each species providing the weighting function. *FQAI* is calculated using the following equation (Andreas et al. 2004; Equation 6):

$$I = \sum\left((cc_i)/\sqrt{N_{(native)}}\right)$$

Where I = the *FQAI* score, cc_{i} = the *C* value of plant, and $N_{(native)}$ = the total number of native species in the site being evaluated. These values can then be compared to other forests that have been evaluated using a *FQA* assessment.

Ohio Rapid Assessment Method (ORAM) Condition Ranking

For wetlands in Ohio, the Ohio Rapid Assessment Method (*ORAM*) has been developed as a rapid, semi-quantitative wetland condition ranking tool (Mack 2000a). It was developed as part of the wetland regulatory program and the metrics are based on function, sensitivity to disturbance, rarity, and irreplaceability. Three main categories were established: Category 1 wetlands have minimal wetland function and/or integrity; Category 2 wetlands have moderate wetland function and/or integrity; and Category 3 wetlands are those with superior wetland function and/or integrity (Mack et al. 2000a). Two hundred and fifty wetlands at CUVA were evaluated using the *ORAM* methodology in 2016 (pers. comm. Roy Cook, December 2016). The metrics used in the quantitative rating and partitioning of the score are provided in Table 4.7-6.

Table 4.7-6. *ORAM* metrics in quantitative rating and the partitioning of the score (Mack et al. 2000a).

Metric	Title	Submetric	Submetric maximum	Metric maximum	Weighting value for this metric
1	Wetland Size	None	6	6	6%
2	Upland buffers and surrounding land use	2a Average buffer width	7	14	14%
	Upland buffers and surrounding land use	2b Surrounding Land Use	7	–	–
3	Hydrology	3a Sources of Water	11	30	30%
	Hydrology	3b Connectivity	3	–	–
	Hydrology	3c Max water depth	3	–	–
	Hydrology	3d Duration inundation or saturation	4	–	–
	Hydrology	3e Modifications to natural hydrologic regime	12	–	–
4	Habitat alteration and development	4a Substrate Disturbance	4	20	20%
	Habitat alteration and development	4b Habitat development	7	–	–
	Habitat alteration and development	4c Habitat alteration	9	–	–
5	Special Wetland Communities	None	10+/10−	10	10%
6	Vegetation, Interspersion, Microtopography	6a Wetland vegetation communities	18	20	20%
	Vegetation, Interspersion, Microtopography	6b Horizontal community interspersion	5	–	–
	Vegetation, Interspersion, Microtopography	6c Presence of [Table 4.7-4] invasives	-5	–	–

Table 4.7-6 (continued). *ORAM* metrics in quantitative rating and the partitioning of the score (Mack et al. 2000a).

Metric	Title	Submetric	Submetric maximum	Metric maximum	Weighting value for this metric
6 (cont.)	Vegetation, Interspersion, Microtopography	6d Microtopography	12	–	–

White-tail Deer Population

White-tail deer (*Odocoileus virginianus*) management has been a resource management concern at CUVA for over 20 years. The effects of excessive deer results in over browsing of vegetation, which has influenced forest regeneration and impacted native species diversity. Although the deer population fluctuates from year to year, long-term deer densities have remained well above levels that are desirable for forest health and regeneration. The current deer density at CUVA is estimated to be 2 to 4 times higher than densities shown elsewhere that are typically associated with adversely impacted forest ecosystems due to excessive deer numbers (Alverson et al. 1988, Tilghman 1989, Anderson 1994, deCalestra 1994 and 1995 (as cited in Fulton et al. 2004)). Studies at CUVA have shown excessive browsing by deer severely impede the growth of seedlings and limit the height of tree seedlings. Preferential browsing by deer on oak saplings are contributing to a decline in the size of larger diameter oak trees within Ohio forests (Widmann et al. 2009). Over browsing by deer has also been shown to suppress native herbaceous cover, limit biodiversity, and affect the regeneration of woody species in the understory. The vegetation inventory project for CUVA, for example, listed excessive deer browse as a disturbance in five upland and four bottomland forest communities at CUVA (Hop et al. 2013). Impacts to forest vegetation from excessive deer browsing has also been shown to reduce the numbers and diversity of songbirds and understory birds within an area (Petit 1998, NPS 2014). Impacts associated with white-tailed deer at CUVA have been summarized in the *Final White-tailed Deer Management Plan and Environmental Impact Statement* (plan/EIS) for CUVA (NPS 2014). The purpose of the plan is to support long-term protection, preservation, and restoration of native vegetation and other natural and cultural resources in CUVA. Management options outlined in the preferred alternative (Alternative D) of the EIS includes construction of large forest exclosures to aid in forest regeneration, implementing reproductive controls in does if an acceptable control is available, implementing direct population reduction methods (shooting, capture, euthanasia), and attempting to maintain target population levels through similar controls (NPS 2014). In addition to implementing management controls, the park will also continue deer population and vegetation monitoring activities (NPS 2014). Management options identified in the management plan/EIS were initiated in early 2018 (NPS 2018).

Forest Pests and Diseases

Forest pest and diseases are a natural and important part of a forest ecosystem. Native insect and pathogens remove some trees from the canopy allowing for new forest growth and nutrient cycling to occur. This process of forest regeneration and recycling of nutrients has occurred for a millennia and is essential for healthy, stable forest ecosystems (Stolte 1997). Historically, native forest pests and diseases were regulated by a number of biotic and abiotic factors including host abundance, host condition, soil, climate, and disturbance history (Berryman 1986). Currently, changes in forest management, climate, and the introduction of exotic insects and diseases have altered the pathogen – host interaction in many forest ecosystems leading to decreases in forest health (Vitousek et al. 1996). Forest pest and pathogens can influence forest dynamics (i.e., forest patterns and processes) by causing defoliation and mortality. These effects may occur at small scales (individual tree or gap phase) or at broad landscape scales and can occur at any seral stage (Castello et al. 1995).

Forest ecosystems at CUVA have a long and varied history of impacts associated with forest pests and pathogens, effectively shaping today's forests. For example, the American chestnut (*Castanea dentata*) was once a dominant canopy species of the Eastern Deciduous Forest until it was wiped out by the chestnut blight (*Cryphonectria parasitica*) in the early to mid-20th century (ODNR 2017b). Similarly, the American elm (*Ulmus americana*), another important component of the eastern hardwood forests, has been nearly eliminated by the fungal Dutch elm disease (*Ophiostoma novo-ulmi*). Other disease and pest issues such as the anthracnose fungus, gypsy moth (*Lymantria dispar dispar*) and beech bark disease (*Nectria coccinea*) have increased the mortality of overstory trees. The result of these disturbances is a forest that is very different from the forest that once covered much of the Allegheny Plateau.

Impacts associated with forest disease and pest issues were assessed using the following: forest vulnerability project results for CUVA (Fisichelli et. al 2014); the *Final Gypsy Moth Management Plan and Environmental Assessment (Plan/EA) for CUVA* (NPS 2000); the *Final White-tailed Deer Management Plan and Environmental Impact Statement (Plan/EIS) for CUVA* (NPS 2014); and the vegetation inventory assessment for CUVA (Hop et al. 2013). Information from the 2013–2027 National Insect and Disease Risk Map (NIDRM) (Krist et al. 2014) was also used to identify potential looming or emerging diseases and pests. The NIDRM is a nationwide, science-based, administrative planning tool that, through a highly collaborative process with experts within the forest health community, determines the severity and extent of tree-mortality hazards due to disease and pathogen issues (Krist et al. 2014). The NIDRM represents 186 individual insect and disease hazard models integrated within a common GIS-based, multi-criteria framework, to provide a consistent, repeatable, transparent, and peer-reviewed process through which interactive spatial and temporal forest health hazard assessments can be conducted. The NIDRM has been applied to all 50 states and has been shown to effectively account for regional variations in forest health (Krist et al. 2014).

<u>Forest Vulnerability to Climate Change</u>

The NPS manages over 3,400 square miles of forested area within the eastern U.S., so understanding impacts related to climate change is paramount for future management (Fisichelli et al. 2014). Changes in climate are expected to alter forest structure, function, composition, and regeneration with not all species or communities being impacted equally. For instance, there are expected to be a number of "winners" and "losers" at the species and/or community level in the face of a changing climate with some species ranges being reduced, other ranges expanding, and still others being relatively unchanged. Fisichelli et al. (2014) modeled impacts to forest ecosystems at 121 eastern

NPS units spread across the eastern U.S. to understand what the magnitude of potential impacts may be. For this analyses, two climate change scenarios ("least" change and "major" change) for 2070–2099 were evaluated. Results from the analysis were used to evaluate the vulnerability of forest communities at CUVA to climate change.

4.7.3. Reference Conditions

Reference conditions for upland and bottomland forests are those that are thought to have existed before forest structure and function were altered by Euro-American settlers. The ideal conditions at CUVA would include intact virgin forests with very low levels of anthropogenic disturbance and low to no cover of non-native species. Because this type of reference condition is not feasible for a unit with the history and extent of CUVA, we instead consider a baseline reference condition as a "best attainable condition" (Stoddard et al. 2006) under which the composition, diversity, and structure of forest vegetation at CUVA is sufficient to maintain the plant community in a stable or improving condition. The reference condition rating framework applied to CUVA forest indicators is shown in Table 4.7-7.

Table 4.7-7. Reference condition rating framework for upland and bottomland forest indicators at CUVA Thresholds based on professional opinion of the authors and published information.

Forest Type	Indicator	Reference, High Quality or Good Condition	Condition Warrants Moderate Concern	Urban Natural, Degraded, Condition Warrants Significant Concern
Upland Forests	Composition (% of species native)	≥75%	74–60%	< 60%
	Mean Coefficient of Conservatism ($\overline{C}$)	≥4.5	3.5–4.5	<3.5
	Invasive Exotic Plants	< 10% IEP Cover	10–25% IEP Cover	> 25% IEP Cover
	Floristic Quality Assessment Index (*FQAI*)	≥45	15–45	<15
	Deer Population	15–30 deer / sq. mile	30–40 deer / sq. mile	>40 deer / sq. mile
	Forest Pests and Disease	<20% of the forested land is in imminent risk of abnormally high levels of tree mortality	20–40% of the forested land is in imminent risk of abnormally high levels of tree mortality	>40% of the forested land is in imminent risk of abnormally high levels of tree mortality

Table 4.7-7 (continued). Reference condition rating framework for upland and bottomland forest indicators at CUVA Thresholds based on professional opinion of the authors and published information.

Forest Type	Indicator	Reference, High Quality or Good Condition	Condition Warrants Moderate Concern	Urban Natural, Degraded, Condition Warrants Significant Concern
Upland Forests (cont.)	Forest Vulnerability to Climate Change	No changes in potential habitat under either change scenario.	Minor predicted increases or decreases in habitat for <10 species with no extirpation being predicated under either change scenario.	Major predicted increases or decreases in habitat for >10 species with species extirpation being predicated under either change scenario.
Bottomland Forests	Composition (% native)	≥75%	74–60%	<60%
	Mean Coefficient of Conservatism $(\overline{C})$	≥ 4.5	3.5–4.5	< 3.5
	Invasive Exotic Plants	<10% IEP Cover	10–25% IEP Cover	>25% IEP Cover
	Floristic Quality Assessment Index (*FQAI*)	≥45	15–45	<15
	ORAM v. 5.0 Score	≥45	30–44.9	<30
	Deer Population	15–30 deer / sq. mile	30–40 deer / sq. mile	> 40 deer / sq. mile
	Forest Pests and Disease	<20% of the forested land is in imminent risk of abnormally high levels of tree mortality	20–40% of the forested land is in imminent risk of abnormally high levels of tree mortality	>40% of the forested land is in imminent risk of abnormally high levels of tree mortality
	Forest Vulnerability to Climate Change	No changes in potential habitat under either change scenario.	Minor predicted increases or decreases in habitat for <10 species with no extirpation being predicated under either change scenario.	Major predicted increases or decreases in habitat for >10 species with species extirpation being predicated under either change scenario.

Species Composition and Diversity

The average percent cover of native species was used to evaluate forest composition, as the presence of non-native species often indicate forest disturbance. The percentage of non-native plant species for national parks units within the Eastern Deciduous Forest is estimated to be between 10% and 50% of the flora with a mean value of 20% (Fisichelli et al. 2014).

Invasive Exotic Plants

Increasing cover of IEP species is thought to be an indicator of a declining condition (Dijuren and Young 2007). In general, IEP cover values above 50% indicate highly disturbed systems, which are typical for most urban areas. Most reclaimed natural areas contain approximately 20% non-native species cover with the range in IEP coverage being determined largely by the type and duration of the disturbance regime. For instance, anthropogenic disturbances have been directly linked to species composition in natural areas located within or adjacent to dense metropolitan areas, with these sites often containing non-native species cover in excess of 40% (Kowarik 2008, Smith and Kuhn 2015).

The ideal condition for forest communities at CUVA would be the complete absence of non-native species, representing conditions during pre-settlement times. Because this type of reference condition is not feasible for a unit with the history and extent of CUVA, we instead consider a baseline reference condition as a "best attainable condition" (Stoddard et al. 2006) under which the composition, diversity, and structure of forest vegetation at CUVA is sufficient to maintain the plant community in a stable or improving condition. In order to quantify "best attainable condition," we use guidance from Potyondy and Geier (2011), which states that forest communities at CUVA should contain less than 10% cover of terrestrial invasive species in order to be rated as "good or functioning properly".

Floristic Quality Assessment Index (FQAI) and Coefficient of Conservatism

The *FQA* metrics (e.g., *FQAI*, $\overline{C}$), reflect the "quality" or "naturalness" of a site (Andreas et al. 2004). Numerous studies have shown the *FQA* approach to be an excellent predictor of plant community condition in both upland and bottomland environments (Swink and Wilhelm 1994, Taft et al. 1997, Fennessy et al. 1998, Mack et al. 2000b, Mack 2001, Lopez and Fennessy 2002, Andreas et al. 2004, Bourdaghs 2004, Bourdaghs et al. 2006, Matthews et al. 2009).

Swink and Wilhelm (1994) developed an *FQA* rating system that rates sites having a $\overline{C}$ value of 3.5 or higher as being of natural quality, while sites having a value of 4.5 or greater are considered high quality natural sites. Sites receiving *FQAI* values of 35 or higher are considered natural sites and sites with values of 45 or higher are "noteworthy" remnant natural areas (Swink and Wilhelm 1994; Rothrock and Homoya 2005). Site $\overline{C}$ and *FQAI* rankings below 3.5 and 35, respectively, are considered to be somewhat degraded, are dominated by lower *C* value species, and are typically affected by periodic anthropogenic disturbances. Floristic quality values have been calculated for a number of Ohio's highest-quality remnant forest stands including some isolated virgin and old-growth stands (Fennessy 1998, Andreas et al. 2004, Gara 2013). Representative *FQAI* scores derived from these quantitative, plot-based sampling efforts from these high quality forest communities in Ohio tend to conform with the Swink and Wilhelm (1994) *FQA* rating system (Andreas et al. 2004).

Based on this, the *FQA* rating system guidance from Swink and Wilhelm (1994) provides a reference benchmark for conditions at CUVA (Table 4.7-7).

Ohio Rapid Assessment Method (ORAM)
The ORAM study aimed to improve understanding of temporal and possibly spatial patterns of average wetland condition across CUVA (pers. comm. Sonia Bingham, 2020). In the ORAM approach, wetlands are ranked using metrics for ecological quality and function. They are typically assigned to one of three main categories based on a scoring protocol (Mack et al. 2000a, 2001). Category 1 wetlands are considered to be "limited quality waters" with limited potential for restoration. Category 2 wetlands are of moderate quality and have a reasonable potential for restoration and support moderate wildlife levels with moderate hydrological functions. These wetlands are dominated by native species but do not typically contain habitat for rare threatened or endangered species. They constitute a broad middle category of "good" quality wetlands. Category 3 wetlands are those that are considered to be superior with high quality habitat, recreational and hydrological functions. They may contain habitat for threatened or endangered species, include high quality mature forested wetlands, vernal pools, bogs, fens, or are otherwise scarce regionally. The interim scoring break points for the wetland regulatory categories for the *ORAM* is provided in Table 4.7-8.

Table 4.7-8. Interim scoring breakpoints for wetland regulatory categories for *ORAM* scores (Mack et al. 2000a). The State of Ohio considers category 2 and higher wetlands to be "good" condition.

Category	*ORAM* v. 5.0 Score (%)
1	0–29.9
1 or 2 gray zone	30–34.9
Modified 2	35–44.9
2	45–59.9
2 or 3	60–64.9
3	65–100

White-tail Deer Population
Reference conditions for forests are those that are thought to have existed before forest structure, function, and regeneration were altered by an overabundance of white-tail deer. The reference condition is based on the deer density goal, as outlined in section 2.2.3 of the white-tail deer Plan/EIS for CUVA (NPS 2014). In determining the deer density goal, the CUVA science team reviewed pertinent scientific research conducted in forest types similar to those in CUVA to determine the approximate number of deer per square mile that would allow for natural forest regeneration and restoration of native species to occur. The science team recommended that the maximum density of deer in the park should not exceed 30 animals per square mile and that the initial deer density range should be between 15 to 30 animals per square mile. It was decided that density target may be adjusted based on adaptive management approaches as a result of vegetation and/or deer population monitoring. In general, 15–30 deer/sq. mile is given a rating of High Quality or Good Condition, a

deer population density of 30–40 deer/sq. mile is given a rating of Moderate Concern, and a deer population density greater >40 deer/sq. mile is given or Significant Concern rating.

Forest Pests and Diseases

Reference conditions for forests are those that are thought to have existed before forest health, structure, and regeneration were altered by exotic forest pest/disease issues and where native disease/pest issues occurred at background levels. Because this type of reference condition is not feasible for a unit with the history and extent of CUVA, we instead consider a baseline reference condition as a "best attainable condition" (Stoddard et al. 2006) under which the composition, diversity, and structure of forest vegetation at CUVA is sufficient to maintain the plant community in a stable or improving condition. In order to quantify "best attainable condition," we use guidance from Potyondy and Geier (2011) which states that less than 20% of the forested land in an area should be at imminent risk of abnormally high levels of tree mortality due to forest disease and pest issues in order to be rated "good or functioning properly." The reference condition rating framework as it relates to forest disease and pest issues at CUVA is shown in Table 4.7-7.

Forest Vulnerability to Climate Change

Modeled data from Fisichelli et al. (2014) was used to assess the vulnerability of CUVA forest ecosystems to changes in climate. This analyses evaluated changes in potential habitat suitability for a variety of tree species based on both a "least change" and a "major change" scenario. The analyses compared forest condition in 1990 (baseline or reference condition) to modeled results for 2017–2099 based on the two scenarios. The reference condition rating system for forest vulnerability to climate change at CUVA is shown in Table 4.7-7. In general, no predicted change in habitat under either climate change scenario is given a rating of High Quality or Good Condition; a minor change in potential habitat for <10 species with no species extirpation being predicted is given a rating of Moderate Concern; and a major change in potential habitat for >10 species with extirpation being predicted for at least some species under either change scenario is given a Significant Concern rating.

4.7.4. Condition and Trend

Native Species Composition

Native species richness for each plot is relatively high at CUVA with upland forest plots averaging 90% native and bottomland forest plots averaging 79.5% native (Figure 4.7-4). The native species composition metric indicates good condition in both upland and bottomland forests, with an unchanging trend and a medium level of confidence.

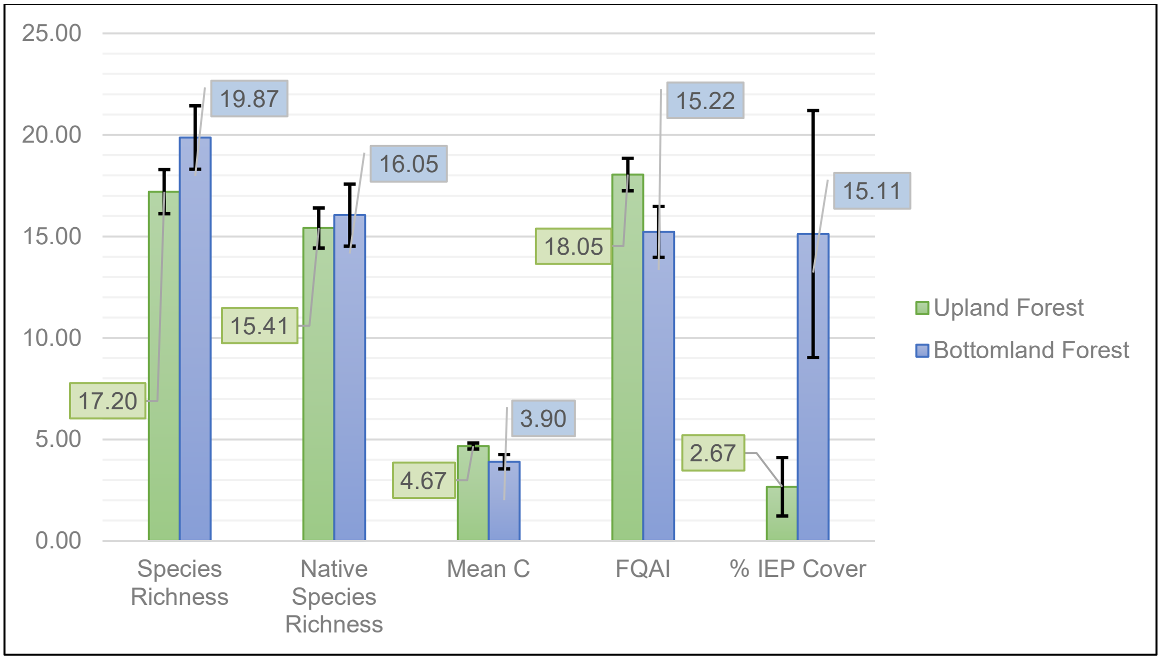


Figure 4.7-4. Means with 90% confidence intervals for forest condition metrics for upland (green bars) and bottomland (blue bars) forests at CUVA. Means were calculated using plot data from the vegetation classification and mapping project (Hop et al. 2013).

Invasive Exotic Plants (IEP)

Using the Hop et al. (2013) data, upland forest plots averaged 2.67% IEP cover and bottomland forest plots averaged 15.11% IEP cover for sixteen species of greatest management concern (Figure 4.7-4). IEP cover occurred only in the herbaceous or shrub stratum as there were no invasive species reported within the forest canopy. Heartland Network surveys conducted in 2007 and 2016 identified 61 invasive exotic plant species at Cuyahoga Valley National Park. No taxa showed meaningful evidence for a decline since 2007. Multiflora rose and reed canarygrass accounted for the majority of invasive plant cover in the park, covering at least 294 and 257 acres, respectively. Multiflora rose and garlic mustard are the most widespread species in the park, occurring in 91% and 67% of the 822 transects surveyed in 2016. Japanese stilt grass is a standout among species surveyed; it was not observed in the 2007 survey, yet it now covers between 66 and 930 acres in the park. Of the 56 invasive exotic plants recorded in the 2016 survey, 44 species occurred in less than 20% of the 822 transects and six species occupied less than one acre.

While the rapid spread of some species is concerning, the relatively low cover of many other species is encouraging and suggests that successful control may be a viable management option (Morgan et al. 2018). Applying the rating system from Potyondy and Geier (2011), the average percent IEP cover metric for bottomland forest warrants moderate concern, with an unchanging trend, and a medium level of confidence. Upland forest is assigned a good condition, with an unchanging trend and medium confidence.

Floristic Quality Assessment Index (FQAI)

The current condition of the forests at CUVA, as reflected by *FQAI*, indicates moderate concern. *FQAI* scores for upland forest plots at CUVA averaged 18.05 and bottomland forest plots averaged 15.22 (Figure 4.7-4). Most *FQAI* scores were between 10 and 30, with values greater than 45 considered high quality sites (Gara 2013, Andreas et al. 2004). When the *FQA* rating system metric from Swink and Wilhelm (1994) is applied, the condition of both upland and bottomland forest plots at CUVA warrant a moderate concern, with an unchanging trend and medium confidence level.

Mean Coefficient of Conservatism ($\overline{C}$)

The average plot $\overline{C}$ score was 4.67 for 109 upland forest plots and 3.90 for the 62 bottomland forests plots at CUVA (Figure 4.7-4). When the *FQA* rating system metric from Swink and Wilhelm (1994) is applied, upland forest plots at CUVA are assigned a good condition and bottomland forest plots warrant moderate concern. Based on the available data, the $\overline{C}$ metric is assigned a good condition for upland forest and moderate concern for bottomland forest. Both conditions are assigned an unchanging trend and there is a moderate level of confidence in the assessment.

Ohio Rapid Assessment Method (ORAM) Condition Ranking

Forested wetlands at CUVA were rated as good condition (Category 2) with a score of 51.15% (pers. comm. Roy Cook, December 2016). Forested wetlands at CUVA accounted for 84.95 wetland acres (24.7% of the total CUVA wetland acres). While forested wetlands at CUVA fell into the Category 2 ranking, some sites did contain rare plant species that are considered to be state threatened or potentially threatened. Based on the available data, the *ORAM* metric warrants a good condition with an unchanging trend and a medium level of confidence.

White-tail Deer Population

Natural resource managers at CUVA began monitoring white-tail deer population trends, density, and health at the park as well as impacts from deer to other natural resources through a variety of research and long-term monitoring projects starting in 1990. These surveys have included; spotlight surveys (1990-present); spotlight survey with density estimation using DISTANCE sampling (1998-present); fecal-pellet-group survey (1995-present); herd health survey (1997–2001); forest/field exclosure monitoring (1991–2013); trillium (*Trillium grandiflorum*) monitoring through paired plots studies (fenced vs. unfenced, 1996–2013); long-term ecological monitoring plots (1998–2013); and forest understory bird monitoring (1997–2000) (NPS 2014).

Deer population densities (deer/sq. mile) at CUVA averaged 54.48 deer/sq. mile over a 16-year period from 1998 to 2013 (Figure 4.7-5) (NPS 2014). Deer varied from a low of 29.3 deer/sq. mile in 2012 to a high of 87 deer/sq. mile in 1999 (NPS 2014).

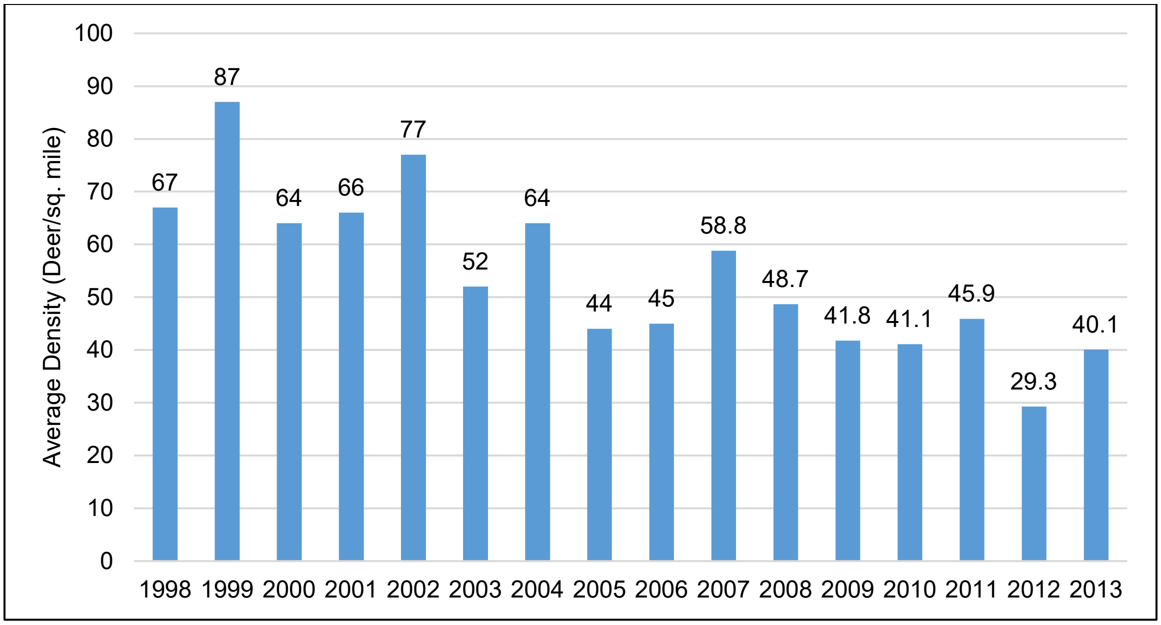


Figure 4.7-5. CUVA white-tail deer population density (deer/sq. mile) from 1998 to 2013. Data from the CUVA *Final White-tailed Deer Management Plan and Environmental Impact Statement* (NPS 2014).

Numerous studies within Eastern Deciduous Forest ecosystems have shown that browsing by white-tailed deer can severely impact forest regeneration success when population densities are greater than 15–20 animals/sq. mile (Hough 1965, Behrend et al. 1970, Marquis 1981, Tilghman 1989, Augustine and deCalestra 2003, Bowersox et al. 2002, Horsley et al. 2003, Sage et al. 2003). Excessive deer browsing tends to impact forest regeneration in three primary ways. First, excessive deer browsing results in vegetation reproduction failure when seedlings are killed. Slow growing/slow maturing species are especially susceptible to this impact. Secondly, forest species composition can be altered over time when deer browse on certain preferred species, indirectly creating opportunities for less preferred/unpalatable species to proliferate and eventually dominant the canopy. Finally, excessive deer browsing over time can lead to the extirpation of highly palatable plants, especially those that are naturally uncommon or only occur locally (Langdon 1985).

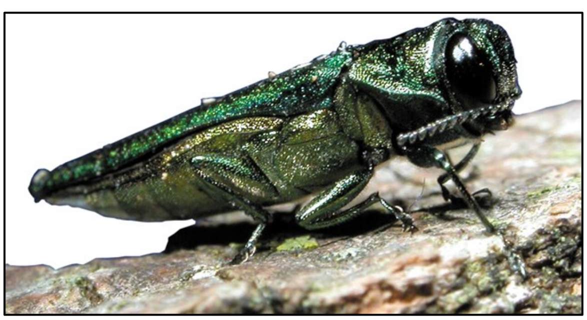
Long-term data collected by CUVA tends to support this trend. For example, the average stem height of trillium was consistently taller within exclosures versus unfenced or browsed areas. Stems measured within the browsed areas consistently fell below the recommended height required for trillium to flower and reproduce suggesting that excessive deer browsing may be impacting trillium vigor over time (NPS 1996). Similarly, data from a paired plot exclosure study found that seedling height was consistently taller in fenced vs. unfenced areas and that the average number of tall seedlings (> 39 inches) was consistently greater in fenced vs. unfenced areas (NPS 2014). These studies describe actual or potential impacts of excessive deer browsing on CUVA forest regeneration (NPS 2014).

Based on the best available data, the white-tail deer population at CUVA far exceeds the deer density management objective of 15–30 animals per square mile outlined in the Plan/EIS. When the indicator rating is applied to this data, white-tail deer population condition warrants significant concern. As management options are implemented, the condition for this indicator should improve, so an improving trend is anticipated. Based on the recent comprehensive examination of this indicator, we have a high level of confidence in the assessment.

Forest Pests and Disease

CUVA forest ecosystems have been impacted by a variety of forest pests and pathogens over time. For example, the American chestnut (*Castanea dentata*) was once a dominant canopy species of the Eastern Deciduous Forest until it was wiped out by the chestnut blight (*Cryphonectria parasitica*) in the early to mid-20th century (ODNR 2017b). Similarly, the American elm (*Ulmus americana*), another important component of the eastern hardwood forests, has had its dominance decimated by the fungal Dutch elm disease (*Ophiostoma novo-ulmi*).

More recently, CUVA forests have been impacted by the gypsy moth (*Lymantria dispar dispar*). Native to Europe, the gypsy moth was introduced to the North America in 1869 and has since impacted forest ecosystems across the eastern U.S. (NPS 2000). The gypsy moth is a voracious defoliator and, while it favors oak species, it will also impact a variety of eastern hardwoods such as birch, basswood, boxelder, maple, hickory, and beech. In 1999, over 4,000 acres of CUVA forest were defoliated by gypsy moths, which led CUVA resource managers to develop and implement the *Final Gypsy Moth Management Plan and Environmental Assessment* (NPS 2000). Defoliation by gypsy moths directly impacts trees by reducing their health and vigor, and leading to an increased susceptibility to other diseases and pest, potentially resulting in tree mortality. Defoliation and the resulting loss of mature forest can change community structure and function, impact water quality, and reduce the quality of habitat available for wildlife species (NPS 2000). Future impacts to CUVA could be significant as the preferred forest type for gypsy moths are oak forests which make up approximately 70% of the CUVA forest cover (NPS 2000). The U.S. Forest Service (USFS) conducts annual aerial surveys to quantify gypsy moth defoliation (NPS 2000). No evidence of a significant gypsy moth infestation has been documented within CUVA since 2001 (NPS 2014).



Emerald Ash Borer (*Agrilus planipennis*). Photo courtesy of NPS.

Another species that is just beginning to impact CUVA forest is the emerald ash borer (*Agrilus planipennis*), or EAB, which has recently been documented within park by APHIS. EAB is a wood-boring beetle that kills ash trees 3 to 5 years after initial infestation. An infestation only becomes evident once the canopy thins due to branch die back, just as the tree begins to die. EAB has already killed millions of ash trees across the eastern U.S. and is found in every county in Ohio.

Including the above disease and pest issues, Fisichelli et al. (2014) identified 47 exotic tree pests and diseases that are/could be at CUVA including 27 that have been detected at the statewide level and 20 that are known to occur at the county level for CUVA. Tree species impacted by these diseases and pests include, but are not limited to, the eastern hemlock (*Tsuga canadensis*), red and white oak species (*Quercus* spp.), ash species (*Fraxinus* spp.), beech (*Fagus grandifolia*), American elm (*Ulmus americana*.), eastern white pine (*Pinus strobus*), and Sugar maple (*Acer saccharum*).

According to the modeled results from the 2013–2027 National Insect and Disease Risk Map (NIDRM) (Krist et al. 2014), approximately 455 acres of CUVA forest are thought to be susceptible to levels of tree mortality in excess of 25% over the 15-year period running from 2013 to 2027. These results also indicate that 5% of all tree biomass at CUVA is at risk to forest pest over this period. Modeled impacts to specific species at CUVA include a 34% decline in ash species due to EAB, a 32% decline in eastern hemlock due to the hemlock woolly adelgid (*Adelges tsugae*), a 21% decline in beech due to beech bark disease, and a 20% decline in American elm due to Dutch elm disease (Figure 4.7-6) (Krist et al. 2014).

Additionally, 16% and 12% reductions in basal areas of oak and maple species, respectively, are expected due to oak decline and maple decline (Krist et al. 2014). All modeled results assume no active management over the timeframe (Krist et al. 2014).

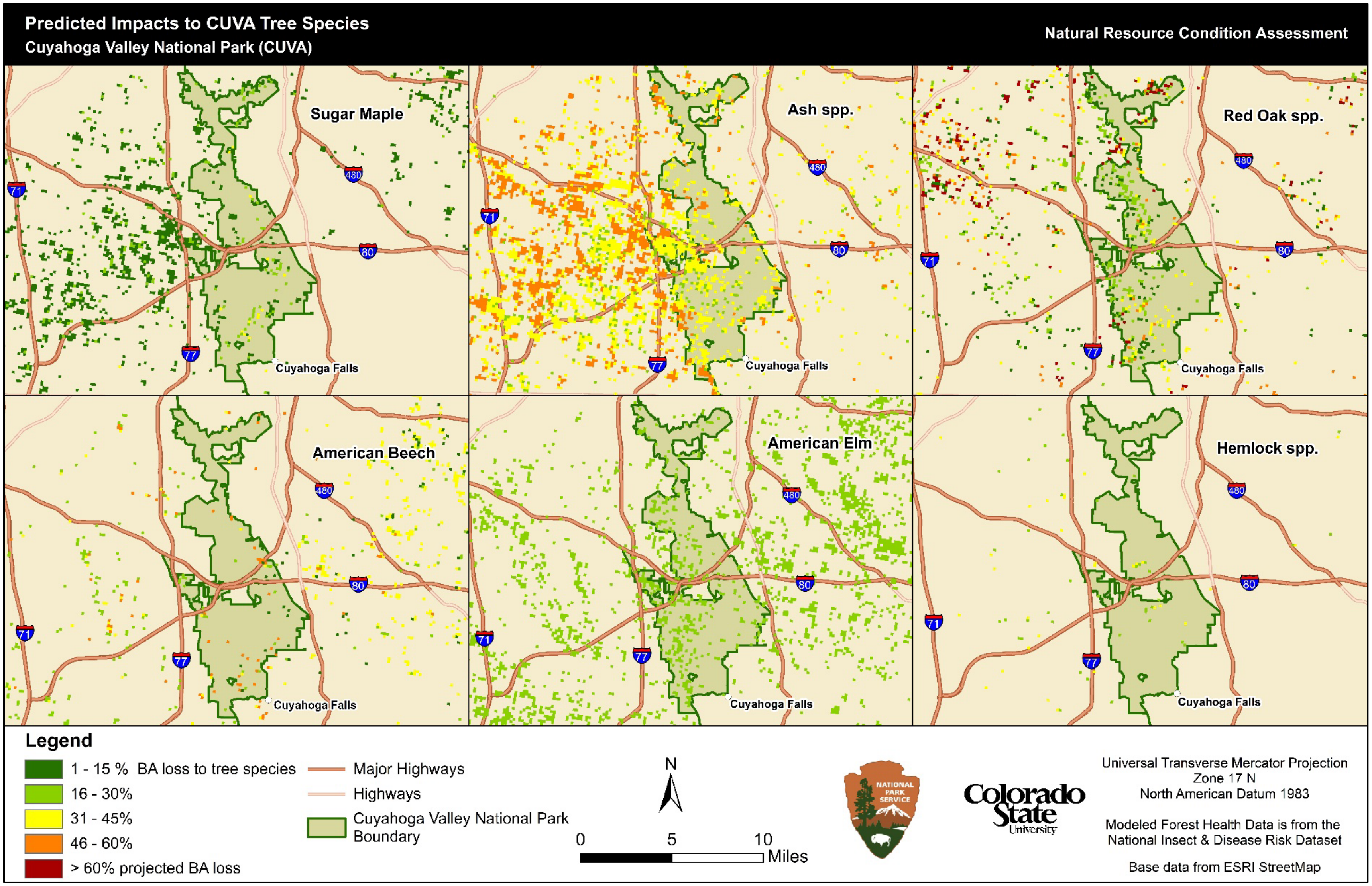


Figure 4.7-6. Modeled predicted impacts to individual tree species from 2013 to 2027 at CUVA based on the results of the NIDRM (Krist et al. 2014). Graphic illustrates predicted loss in tree basal area (BA) due to a variety of forest disease and pest issues.

Based on the best available data, including modeled data from the NIDRM, only 5% of the tree biomass is modeled to be at risk over the 2013 to 2027 timeframe, well below the 20% threshold for moderate condition. However, modeled impacts to individual species (e.g., 34% decline in ash species, 32% decline in hemlock) are likely to significantly impact forest structure and dominance in some areas. For this reason, the condition warrants moderate concern. A deteriorating trend is assigned due to ongoing impacts and forecasted future impacts as pest species become more established in the CUVA area (e.g., EAB). Due to the modeled nature of this data, a low level of confidence is assigned.

Forest Vulnerability to Climate Change

Modeled changes in CUVA's climate were generated for two scenarios (Table 4.7-9). Predicted impacts to CUVA forests based on modeled data from Fisichelli et al. (2014) are substantial (Table 4.7-10). The "least change" scenario represents strong cuts in greenhouse gas emissions and modest climatic changes and the "major change" scenario represents continued increasing greenhouse gas emissions and rapid warming. Change class designations are based on the ratio of future (2100) to baseline (1990) habitat suitability and baseline habitat values, (e.g., for common species, large decrease is ≤ 0.5, small decrease is > 0.5 and ≤ 0.8, no change is > 0.8 and ≤ 1.2, small increase is > 1.2 and ≤ 2.0, and large increase is > 2.0). Modeled results indicate that 15 species will face small-to-large decreases in potential habitat based on the two climate change scenarios. Additionally, several of these species are predicted to face extirpation by the year 2100 regardless of scenario (i.e., *Fraxinus nigra*, *Populus tremuloides*, and *Tsuga canadensis*). Alternatively, 10 species are predicted to increase in range by 2100, and 3 species are predicted to have no change in their potential habitat under either climate change scenario (Table 4.7-10). Predicted impacts from climate change were not always straightforward, as 20 species were predicted to have mixed impacts from the two scenarios. Fisichelli et al. (2014) also predicted 16 new species ranges could expand into CUVA resulting in new species or communities occurring within the park by the year 2100. While the exact degree of impacts from climate change to individual species is unknown at CUVA, modeled results from Fisichelli et al. (2014) paint a likely picture that CUVA forest communities will be dramatically different in the future in the face of a changing climate.

Based on the best available data, the forest vulnerability to climate change indicator at CUVA appears to warrant significant concern. Major increases or decreases in potential habitat range are being predicted for over 50 individual tree species with a number of species facing extirpation under either one or both the two climate change scenarios. A deteriorating trend is assigned due to the high potential for future impacts to CUVA forest communities from climate change. We assign a low level of confidence to this assessment due to the modeled nature of the data.

Table 4.7-9. Modeled changes in climate from baseline (1961–1990) to future (2070–2099) based on two climate change scenarios. This data was used to predict impacts to individual tree species at CUVA (Fisichelli et al. 2014).

Climate Variable	Baseline (1961–1990)	Least Change (2070–2099)	Major Change (2070–2099)
Mean annual temperature	8.9 °C (48.1 °F)	+2.5 °C (+4.5 °F)	+7.6 °C (+13.7 °F)
Mean January temperature	−3.8 °C (25.2 °F)	+1.9 °C (+3.4 °F)	+6.4 °C (+11.5 °F)
Mean July temperature	21.3 °C (70.3 °F)	+2.2 °C (+4 °F)	+8.7 °C (+15.7 °F)
Seasonality (July–January temp.)	25.1 °C (45.1 °F)	+0.3 °C (+0.6 °F)	+2.3 °C (+4.2 °F)
Mean May–September temp.	18.3 °C (65 °F)	+2.4 °C (+4.3 °F)	+8.2 °C (+14.7 °F)
Annual precipitation	953 mm (37.5 in)	+12.30%	+11.30%
May–September precipitation	466 mm (18.3 in)	+12.60%	−2.90%

Table 4.7-10. Modeled predicted changes in potential habitat for tree species at CUVA (2100 compared with 1990) based on data from Fisichelli et al. (2014). Species are grouped based on change class designations for two future climate scenarios.

Potential Habitat Change	Scientific Name	Common Name	Least Change	Major Change
Decreases in Potential Habitat	*Acer nigrum*	black maple	large decrease	large decrease
	Acer rubrum	red maple	small decrease	large decrease
	Carpinus caroliniana	American hornbeam	small decrease	small decrease
	Fraxinus nigra	black ash	extirpated	extirpated
	Magnolia acuminata	cucumbertree	large decrease	extirpated
	Ostrya virginiana	eastern hophornbeam	small decrease	large decrease
	Pinus resinosa	red pine	large decrease	large decrease
	Pinus strobus	eastern white pine	small decrease	extirpated
	Populus grandidentata	bigtooth aspen	large decrease	extirpated
	Populus tremuloides	quaking aspen	extirpated	extirpated
	Prunus serotina	black cherry	large decrease	extirpated
	Quercus bicolor	swamp white oak	small decrease	extirpated
	Quercus rubra	northern red oak	small decrease	large decrease
	Tilia americana	American basswood	small decrease	extirpated
	Tsuga canadensis	eastern hemlock	extirpated	extirpated

Table 4.7-10 (continued). Modeled predicted changes in potential habitat for tree species at CUVA (2100 compared with 1990) based on data from Fisichelli et al. (2014). Species are grouped based on change class designations for two future climate scenarios.

Potential Habitat Change	Scientific Name	Common Name	Least Change	Major Change
No Change in Potential Habitat	*Acer negundo*	boxelder	no change	no change
	Acer saccharinum	silver maple	no change	no change
	Carya tomentosa	mockernut hickory	no change	no change
Increases in Potential Habitat	*Carya cordiformis*	bitternut hickory	large increase	large increase
	Celtis occidentalis	hackberry	large increase	large increase
	Cercis canadensis	eastern redbud	large increase	small increase
	Fraxinus pennsylvanica	green ash	large increase	large increase
	Gleditsia triacanthos	honeylocust	large increase	large increase
	Juniperus virginiana	eastern redcedar	large increase	large increase
	Maclura pomifera	osage-orange	large increase	large increase
	Nyssa sylvatica	blackgum	small increase	small increase
	Platanus occidentalis	sycamore	large increase	small increase
	Quercus velutina	black oak	small increase	small increase
Mixed Results	*Acer saccharum*	*sugar maple*	small increase	extirpated
	Carya glabra	*pignut hickory*	no change	small decrease
	Carya ovata	*shagbark hickory*	large increase	no change
	Cornus florida	*flowering dogwood*	small increase	no change
	Fagus grandifolia	*American beech*	no change	large decrease
	Fraxinus americana	*white ash*	no change	large decrease
	Juglans nigra	*black walnut*	large increase	large decrease
	Liquidambar styraciflua	*sweetgum*	no change	large increase
	Liriodendron tulipifera	*yellow-poplar*	small increase	large decrease
	Populus deltoides	*eastern cottonwood*	small decrease	small increase
	Quercus alba	*white oak*	small increase	no change
	Quercus coccinea	*scarlet oak*	small increase	large decrease
	Quercus macrocarpa	*bur oak*	extirpated	large increase
	Quercus palustris	*pin oak*	no change	small decrease
	Quercus prinus	*chestnut oak*	large increase	small decrease
	Robinia pseudoacacia	*black locust*	no change	large decrease
	Salix nigra	*black willow*	no change	large decrease
	Sassafras albidum	*sassafras*	small increase	small decrease

Table 4.7-10 (continued). Modeled predicted changes in potential habitat for tree species at CUVA (2100 compared with 1990) based on data from Fisichelli et al. (2014). Species are grouped based on change class designations for two future climate scenarios.

Potential Habitat Change	Scientific Name	Common Name	Least Change	Major Change
Mixed Results (cont.)	*Ulmus americana*	*American elm*	no change	large decrease
	Ulmus rubra	*slippery elm*	no change	large decrease
New Potential Habitat	*Carya illinoinensis*	pecan	–	new entry
	Carya texana	black hickory	new entry	new entry
	Celtis laevigata	sugarberry	–	new entry
	Diospyros virginiana	common persimmon	new entry	new entry
	Morus rubra	red mulberry	new entry	new entry
	Pinus echinata	shortleaf pine	–	new entry
	Pinus taeda	loblolly pine	–	new entry
	Quercus falcata var. *falcata*	southern red oak	–	new entry
	Quercus imbricaria	shingle oak	new entry	new entry
	Quercus marilandica	blackjack oak	new entry	new entry
	Quercus muehlenbergii	chinkapin oak	new entry	new entry
	Quercus nigra	water oak	–	new entry
	Quercus shumardii	Shumard oak	–	new entry
	Quercus stellata	post oak	new entry	new entry
	Ulmus alata	winged elm	–	new entry
	Ulmus crassifolia	cedar elm	–	new entry

Overall Condition

Results consolidated across multiple indicators suggest the current condition of both upland and bottomland forests at CUVA warrants moderate concern, with an unchanging trend and medium confidence. The primary difference in the indicators between upland and bottomland forest is a higher level of invasive exotic plants in the bottomland forests. A summary of results for all indicators is shown in Tables 4.7-11 and 4.7-12.

Table 4.7-11. Condition and trend summary for upland forest communities, Cuyahoga Valley National Park.

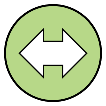
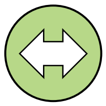
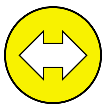
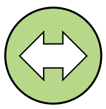
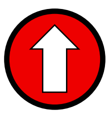
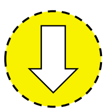
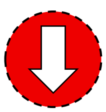
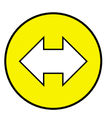
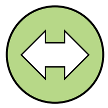
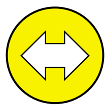
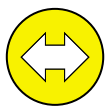
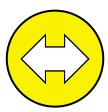
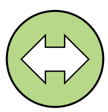
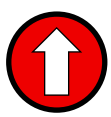
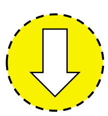
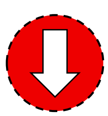
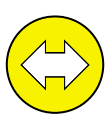
Indicator	Condition Status/Trend	Rationale
Native Species Composition		Native species composition averaged 90% across all upland forest plots at CUVA. Six rare plant communities and 8 state rare plant species are supported in CUVA upland forest.
Invasive Exotic Plants (IEP)		Upland forest plots averaged 2.67% IEP cover.
Floristic Quality Assessment Index (*FQAI*)		Upland forest plots at CUVA averaged 18.05 *FQAI* suggesting a moderate condition.
Mean Coefficient of Conservatism ($\overline{C}$)		The average plot $\overline{C}$ score was 4.67 for upland forest plots at CUVA. Swink and Wilhelm (1994) regarded sites with a $\overline{C}$ > 4.5 as "high-quality" sites.
White-tail Deer Population		The white-tail deer population at CUVA has averaged 54.48 deer/sq. mile over the 1998 to 2013 timeframe, well above the deer density goal for the park. Deer management was initiated in early 2018 so the trend for this indicator should be improving (NPS 2018). Based on the wealth of information for this indicator, a high level of confidence is placed on the assessment.
Forest Pests and Disease		A variety of forest disease and pest issues currently are or are predicted to impact CUVA. The predicted declines in individual species (e.g., 34% decline in Ash spp.) warrant moderate concern. A low confidence level is placed on this assessment due to the modeled nature of the data.
Forest Vulnerability to Climate Change		A number of species are predicted to be severely impacted by a changing climate at CUVA. A low confidence level is placed on this assessment due to the modeled nature of the data.
Upland Forests overall		The condition of upland forests warrants moderate concern with an unchanging trend. Confidence in the assessment is medium.

Table 4.7-12. Condition and trend summary for bottomland forest communities, Cuyahoga Valley National Park.

Indicator	**Condition Status/Trend**	**Rationale**
Native Species Composition		Native species composition averaged 79.5% across all bottomland forest plots at CUVA. Three rare plant communities and 3 state rare plant species are supported in CUVA bottomland forest.
Invasive Exotic Plants (IEP)		Bottomland forest plots averaged 15.11% IEP cover.
Floristic Quality Assessment Index (*FQAI*)		Bottomland forest plots at CUVA averaged 15.22 *FQAI* suggesting a moderate condition.
Mean Coefficient of Conservatism ($\bar{C}$)		The average plot score was 3.90 for bottomland forest plots at CUVA.
Ohio Rapid Assessment Method (*ORAM*)		An average *ORAM* score of 51.15% is indicative of a good quality forested wetlands.
White-tail Deer Population		The white-tail deer population at CUVA has averaged 54.48 deer/sq. mile over the 1998 to 2013 timeframe, well above the deer density goal for the park. Deer management was initiated in early 2018 so the trend for this indicator should be improving (NPS 2018). High confidence is based on the recent comprehensive examination of this topic at CUVA.
Forest Pests and Disease		A variety of forest disease and pest issues are predicted to impact CUVA. The predicted declines in individual species (e.g., 34% decline in Ash spp.) warrants moderate concern. A low confidence level is placed on this assessment due to the modeled nature of the data.
Forest Vulnerability to Climate Change		A number of species are predicted to be severely impacted by a changing climate at CUVA. A low confidence level is placed on this assessment due to the modeled nature of the data.
Bottomland Forests overall		The condition of bottomland forests warrants moderate concern with an unchanging trend. Confidence in the assessment is medium.

Overall trends are difficult to assess but there are factors that indicate current forest conditions will change in the near future. For instance, as white-tail deer management is initiated, impacts related to deer over browsing should subsided resulting in an improved condition. Alternatively, modeled data predicts CUVA forest will be impacted by a variety of disease and pest issues as well as changes in climate with these impacts having the potential to drastically affect future forest composition and structure (Fisichelli et al. 2014). The combined and synergistic effects of these factors along with other anthropogenic disturbances (e.g., fire suppression, urban development, hydrologic changes) will determine the future trajectory of CUVA forest condition.

4.7.5. Uncertainty and Data Gaps

Uncertainty exists with regard to the interactive and synergistic effects of anthropogenic stressors, white-tail deer overabundance, forest health, and climate change impacts. Additional modeling along with continued forest monitoring should be continued to help understand these cumulative impacts and better inform the future makeup of CUVA forest. Other gaps and needs identified in the course of this work and in the CUVA *Foundational Document* include:

- A comprehensive inventory of forest areas exhibiting late successional and old-growth characteristics is recommended. Such areas occur on CUVA, are rare within the state, and often harbor rare species and high levels of diversity;
- Monitoring of vegetation beyond the IEP survey work. There is currently no landscape or community vegetation monitoring in the park;
- Expanded forest restoration, prescribed fire, road removal, species re-introductions, and long-term ecological monitoring; and
- Rare plant inventories and monitoring.

4.7.6. Sources of Expertise

- Roy Cook (ORAM scores) Pers. Comm. 12-21-2016
- Kevin Hop, USGS. Vegetation inventory and mapping project for CUVA.
- Nicholas Fisichelli, NPS Climate Program. Issues related to climate change and forest disease and pests.

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4.8. Bats

4.8.1. Background and Importance

Bats are often inconspicuous components of hardwood riparian forest ecotones and compose an important natural resource within riparian woodland in parks of the Heartland Inventory and Monitoring Network (HTLN). The HTLN facilitates inventories of vascular plants and vertebrates within fifteen parks in eight Midwestern states, including CUVA. Prioritization of inventory needs for CUVA in 2001 determined that a bat inventory, specifically focused on the federally-endangered Indiana bat (*Myotis sodalis*), was a top priority for the park (Krynak et al. 2005). The Indian bat is a migratory species that was initially listed as endangered in 1966 and at the time was known to winter in only nine suitable hibernacula located in Indiana, Kentucky, and Missouri (USFWS 2007, Krynak et al. 2005). The bat is considered to be moderately threatened but may have a high recovery potential with current records from 281 winter hibernacula in 19 states and 269 maternity colonies in 16 states (USFWS 2007). As of 2007, populations of the Indiana bat were increasing regionally, but the species was still in need of intensive conservation (USFWS 2007).

More recently, significant declines have occurred. In North America, bats are threatened by white-nose syndrome (WNS), a fungal disorder caused by the fungus *Geomyces destructans* that can result in the entire loss of a bat colony. The Indian bat is one species confirmed as having WNS. Alves et al. (2014) noted that WNS had killed around six million bats in North America at the time of publication. They identified eight species as threatened by WNS including four that are known to occur at CUVA; the Indian bat, eastern small-footed bat (*Myotis leibii*), tricolored bat (*Perimyotis subflavus*), and big brown bat *(Eptesicus fuscus*) (Alves at al. 2014). Research activities focused on efforts to control human accessibility to bat hibernacula. Preventing the spread of the disease by limiting human activity and decontaminating gear used in hibernacula is key to conserving bat populations in North America and at CUVA (Alves et al. 2014, Frick et al. 2016).

The cave habitat used as hibernacula in both summer and winter at CUVA, as well as mature forest habitat required for foraging and maternity roosting, support both resident and migrating bats. Relative to the metropolitan and surrounding urban areas of Akron and Cleveland, Ohio, the lack of urbanization in CUVA is especially valuable by providing relatively unfragmented patches of native riparian hardwood forest that serve as a refuge within a highly altered landscape. The fragmentation of habitat and conversion of native vegetation to urban landscapes outside the park will negatively impact populations of some bats at CUVA, particularly specialist species that have evolved within stable environments (Keinath et al. 2017, Matthews et al. 2014, Devictor et al. 2008, La Sorte 2006). Bat community composition and diversity should improve with the protection of caves and the restoration of the native riparian hardwood forest communities within CUVA and the surrounding landscape (Johnson 2006, Boren et al. 1999).

<u>Threats</u>

Primary threats to bats at CUVA are the spread of WNS (often accelerated by human activities/contact), disturbance of cave habitat used for both winter hibernacula and summer roosting and the continuing loss of mature forest habitat required for both foraging and maternity roosting (Alves et al. 2014, Krynak et al. 2005). Chronic and widespread habitat modifications disrupt ecological functions important to ecosystem integrity and to maintaining the bat community at CUVA relative to that of the natural habitat of the region (Jorgensen and Müller 2000). Consequently, the ecological functioning of CUVA depends upon maintaining the natural systems within and outside park boundaries. Changes in land use are linked to ecological function by five mechanisms (Hansen and Gryskiewicz 2003):

1. Land use activities reduce the functional size of a reserve, eliminating important ecosystem components lying outside the park boundary;

2. Land use activities alter the flow of energy or materials across the landscape irrespective of the park's administrative boundary, disrupting the ecological processes dependent upon those flows both outside and inside the park and across its boundaries;

3. Habitat conversion outside the park may eliminate unique habitats, such as seasonal habitats and migration corridors;

4. The negative influences of land use activities may extend into the park and create edge effects; and

5. Increased population density may directly impact parks through increased recreation and human disturbance.

<u>Indicators and Measures</u>

- Native species richness (S)

- Occurrence and status of bat species of conservation concern

4.8.2. Data and Methods

Bat surveys were initiated at 35 sites in CUVA in 2002 as research for a PhD being conducted by Tim Krynak at John Carrol University in Ohio (Figure 4.8-1). Field research was conducted through 2003. Follow up studies conducted in 2005 focused on a population of the northern myotis (*Myotis septentrionalis*), which was discovered during the 2002 and 2003 surveys (Krynak 2010, Krynak et al. 2005). Bats were surveyed using standard procedures established by the Indiana Bat Recovery Team and recommended by the U.S. Fish and Wildlife Service (USFWS 1999, Brady et al., 1983). Krynak (2011) conducted a swarming survey of bats in CUVA at Ice Box Cave while he was working as a biologist with Cleveland Metroparks. The research aimed to evaluate swarming activity and to monitor bats at Ice Box Cave for WNS (Krynak 2011). The Ohio Division of Wildlife monitored bats acoustically in CUVA using the same routes since 2011 (Brown 2016). The routes formed an approximately thirty-mile long loop that was driven as close to fifteen miles per hour as possible (Brown 2016). Driving the surveys at this speed supported the assumption that each bat was detected only once (Hayes and Hounihan 1994). Data from these surveys were used to determine the condition of the bat community at CUVA.

The sites and the number of sites surveyed varied by year. There were 17 sites surveyed in 2002, 22 in 2003, 5 in 2004, 13 in 2005, 1 from 2009 to 2011, and 12 in 2015. A total of 45 different sites was surveyed in the five years that sampling occurred and 29 of those sites were only surveyed in one year. Nine sites were surveyed for two years, four for three years, two for four years, and one site was surveyed in all of the five years sampled.

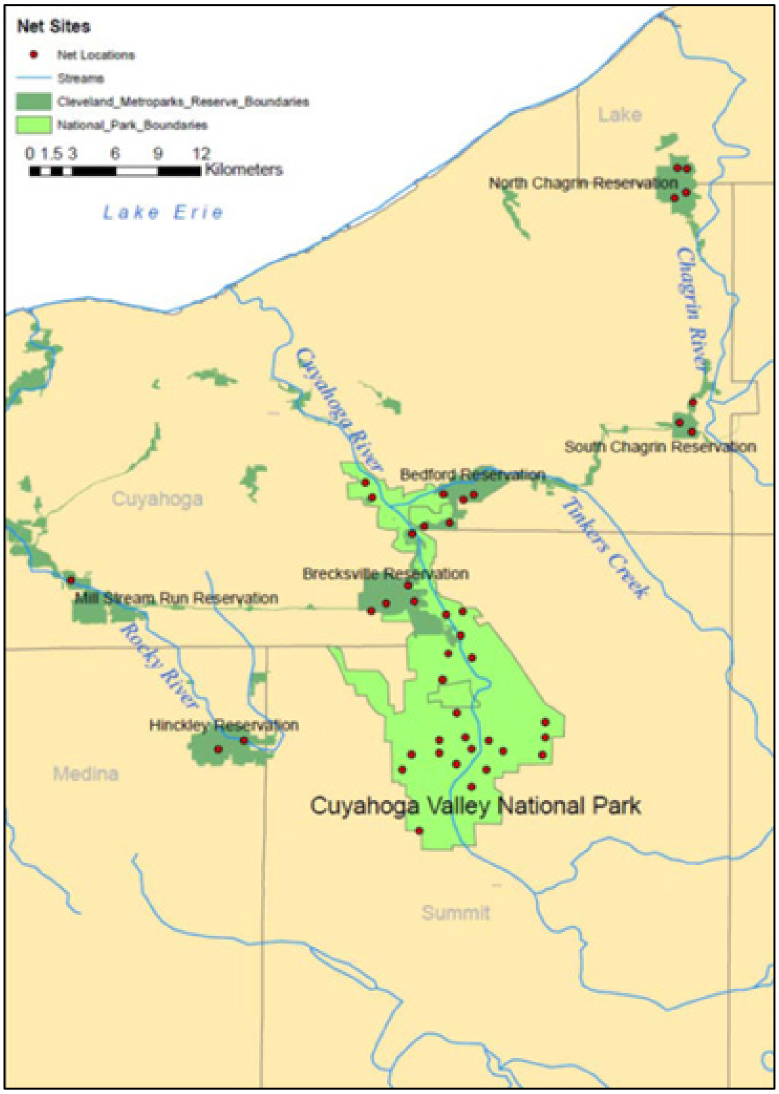

Figure 4.8-1. Bat survey locations, Cuyahoga Valley National Park, Ohio. Location data and map graphic from Tim Krynak (unpublished).

To evaluate trends over time, we compared the occurrence of species detected during the initial survey conducted at CUVA in 2002 to species detected during the 2015 survey. We compared mean species richness per sample site between 2002 and 2015 using only native species.

The Ice Box Cave surveys from 2009 through 2011 were not used in the regression analysis of native species richness. The calculation of mean native species richness per site in those years was not possible because only one site, Ice Box Cave, was surveyed. The five native bat species observed at Ice Box Cave in those years was nearly twice that of the grand mean for the other five sample years, which was 2.9. Including the 2009 to 2011 Ice box cave surveys in the regression analysis would have skewed the results.

To evaluate the occurrence and status of species of conservation concern within the park, we used the occurrence of species listed as either endangered or threatened by the U. S. Fish and Wildlife Service (USFWS); U. S. Forest Service (USFS) and Bureau of Land Management (BLM) sensitive species lists; NatureServe G1 to G3 and S1 ranked species; and State lists of endangered, threatened and special concern species. Our intent was to determine which species that occur at CUVA are considered species of conservation concern at either a national or local scale, to assess the current status (occurrence) of those species at the park, and to evaluate the potential for the park to play a role in conserving those species. This analysis was restricted to those species that were either breeding at the park or that were residents. Those species occurring during migration only and incidental occurrences of species outside of their normal range were excluded. The Ice Box Cave surveys from 2009 through 2011 were not used in the regression analysis of the species of conservation concern for reasons noted above.

4.8.3. Reference Conditions

Little historical survey data exist for CUVA. Bat surveys using mist netting and acoustic sampling were conducted at CUVA from 2002 through 2005, and in 2015 (Brown 2016, Krynak 2010, Krynak et al. 2005). The same sites and the same number of sites were not sampled consistently in the eight years that bat sampling was conducted at CUVA. The initial year of bat surveying at CUVA (2000) is used as a reference for comparison to current bat community quality. Maintaining or exceeding the level of diversity as defined by the initial, 2002, calculation of native species richness (as an index of diversity) and the number of species of conservation concern recorded in 2002 are considered good condition. The condition of the resource is considered higher if more species of concern are observed. This implies that the populations of those species are increasing and/or they are using the park more. A condition rating framework for bats developed by the authors is shown in Table 4.8-1.

Impacts from WNS to bats in the eastern U. S. has resulted in the listing of all of the bat species recorded at CUVA as species of concern at either the federal or state level. Consequently, the outcome of the analysis conducted for native species richness and the species of conservation concern are numerically the same. However, both analyses are still presented here for informative purposes.

Table 4.8-1. Resource condition rating framework for bats at Cuyahoga Valley National Park.

	Condition Status		
Indicator	**Resource is in Good Condition**	**Condition Warrants Moderate Concern**	**Condition Warrants Significant Concern**
Native Species Richness (S)	>85–100+ % of 2002 value	70–85% of 2002 value	<70% of 2002 value
Bat Species of Conservation Concern	>85–100+ % of 2002 value	70–85% of 2002 value	<70% of 2002 value

4.8.4. Condition and Trend

Species Richness

A mean of 1.9 native species was recorded per sampling site in 2015, the most common species was the hoary bat (*Lasiurus cinereus*) (Table 4.8-2, Figure 4.8-2). This total was less than the 3.4 native species per site recorded during the initial 2002 bat survey at CUVA (Table 4.8-2). Native species richness per site at CUVA in 2015 was only 56 percent of that recorded in 2002, indicating the resource warrants significant concern (Table 4.8-2).

Table 4.8-2. Bat species recorded in 2015 and 2002 surveys at Cuyahoga Valley National Park (data from Krynak et al. 2005, Brown 2016).

Common name	Species name	Individuals Detected 2002	Individuals Detected 2015	USFS and Federal ESA List Status[a]	Nature-Serve Rank	State List Status[b]
Big Brown bat	*Eptesicus fuscus*	14	2	–	G5 SNR	C
Eastern Red bat	*Lasionycteris noctivagans*	11	3	–	G3G4 SNR	C
Hoary bat	*Lasiurus cinereus*	1	9	–	G3G4 SNR	C
Indiana bat	*Myotis leibii*	1	1	E	G2 S1	E
Little brown bat	*Myotis lucifugus*	13	0	–	G3 SNR	C
Northern Myotis	*Myotis septentrionalis*	15	2	T	G1G2 SNR	C
Silver-haired bat	*Myotis sodalist*	0	4	–	G3G4 SNR	C
Tricolored Bat	*Perimyotis subflavus*	3	2	–	G2G3 SNR	C

[a] U. S. Fish and Wildlife Service Federal Status – E = listed endangered, T = listed threatened.

[b] State Status – E = state endangered, C = state special concern.

The slope of the linear regression line for mean native bat species richness per site was negative and statistically significant, suggesting a declining trend in the richness of the bat community at CUVA. For the first year that multiple sites were monitored for bats at CUVA, 2002, the 90 percent confidence interval for native species richness per site does not overlap with that same quantity for the last year surveyed, 2015. This also suggests that native bat species richness per site has declined since 2002, when bats were first surveyed at CUVA (Figure 4.8-2).

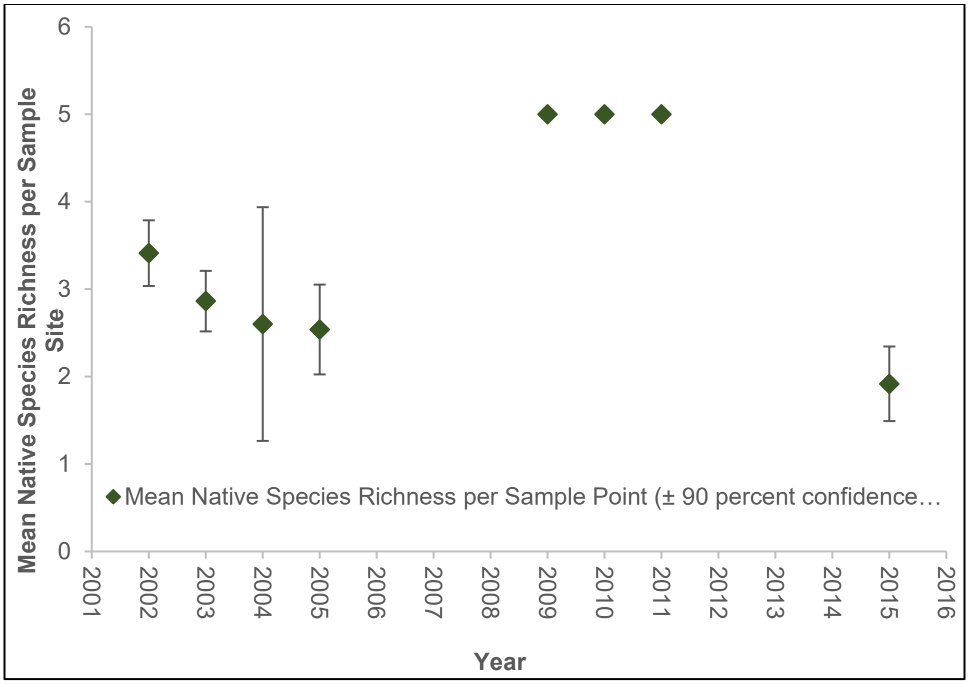

Figure 4.8-2. Means and 90 percent confidence intervals for native bat species richness at Cuyahoga Valley National Park from 2002 to 2015. Ice Box Cave was the only site sampled in 2009, 2010 and 2011 (data from Krynak et al. 2005, Krynak 2010, and Brown 2016).

<u>Species of Concern</u>

There was a mean of 1.9 species of conservation concern per site recorded during the 2015 Ohio Division of Wildlife bat survey, which was 1.5 less than the 3.4 species of conservation concern per site reported in 2002. Eight bat species that are of conservation concern were recorded at CUVA in 2015 (Table 4.8-2). This was the same as the eight bat species of conservation concern recorded in 2002. The most common bat species of conservation concern recorded at CUVA in 2015 was the hoary bat. Most of the species of conservation concern decreased in number from 2002 to 2015 (Table 4.8-2). The number of bat species of conservation concern per site at CUVA in 2015 was only 56 percent of the number per site recorded in 2002, indicating the resource warrants significant concern.

The slope of the linear regression line for mean bat species of conservation concern per site was negative and statistically significant, suggesting a declining trend in the bat species of conservation concern at CUVA. For the first year that multiple sites were monitored for bats at CUVA, 2002, the 90 percent confidence interval for bat species of conservation concern per site does not overlap with that same quantity for the last year surveyed, 2015. This also suggests that the number of bat species of conservation concern per site has declined since 2002, when bats were first surveyed at CUVA (Figure 4.8-2).

<u>Overall Condition and Trend</u>

Data representing native species richness and the number of species of concern indicate that the condition of the bat community at CUVA warrants significant concern, with statistically significant declines in both richness and the species of conservation concern occurring between 2002 and 2015 (Table 4.8-3). The overall condition of the bat community warrants significant concern with a deteriorating trend; confidence in the assessment is low.

Table 4.8-3. Condition and trend summary for bats at Cuyahoga Valley National Park.

Indicator	Condition Status/Trend	Rationale
Native Species Richness (S)		Mean native bat species richness per sample site has fluctuated between 1.9 and 3.4 species from 2002 to 2015 with mean richness equaling 1.9 in 2015 (warrants significant concern), less than the management target of 85 percent of 3.4. Analysis of the bat survey data indicates a declining trend in native species richness from 2002 to 2015.
Species of Conservation Concern		The mean number of bat species of conservation concern per sample site fluctuated between 1.9 and 3.4 species from 2002 to 2015 with mean richness equaling 1.9 in 2015 (warrants significant concern), less than the management target of 85 percent of 3.4. Analysis of the bat survey data indicates a declining trend in the number of bat species of conservation concern from 2002 to 2015.
Bats overall		**Condition warrants significant concern with a declining trend. Confidence in the assessment is low.**

4.8.5. Uncertainty and Data Gaps

Confidence in this assessment was low as is the confidence in the trend analyses. There are two key elements in the way that bats were surveyed at CUVA that create this uncertainty. The first is that the survey methods differed between 2002 and 2015. In the 2002 survey, bats were mist-netted at multiple sites within CUVA. The 2015 survey used acoustic sampling of bats at multiple sites within CUVA. The two methods have the potential to vary in their ability to detect the bats that are actually present. This would bias any comparisons of the condition indicators between the two years evaluated. This assessment is based upon monitoring data collected over multiple years by multiple trained volunteer observers with varying skills in conducting bat surveys. This variation could introduce measurement error into the data, leading to bias in the data. This bias can reduce the ability to identify statistically significant trends in the indicators (Dornelas et al. 2012). Moreover, the bias associated with data collection can be minimized by thoroughly training volunteers on the data collection methods, but that does not reduce the bias resulting from the turnover in collectors over multiple years.

4.8.6. Sources of Expertise

Tim Krynak, a natural resources manager at Cleveland Metroparks, has conducted bat surveys at CUVA beginning in 2002 and is an expert on the parks bat community. Meg Plona is the NPS biologist at Cuyahoga Valley National Park and has worked closely with Tim Krynak on implementation of the CUVA bat surveys.

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4.9. Riparian Birds

4.9.1. Background and Importance

Birds are conspicuous components of eastern hardwood forests and comprise an important natural resource within riparian woodland parks of the Heartland Inventory and Monitoring Network (HTLN). Riparian woodland and wetland birds of the Great Lakes region have been in decline since the 1970s (Tozer 2013, Rosenberg et al. 2016, Sauer et al. 2017). This decline has been attributed to multiple factors, including habitat loss due to urbanization and recreation; habitat degradation through forest fragmentation and invasive species; and increasing human-caused mortality from collisions with structures and domestic cat predation (Potter et al 2007a, Potter et al. 2007b, Soulliere 2007, Rosenberg et al. 2016). The NPS formally recognizes this decline and the need to understand the long-term trends in community composition and abundance of breeding bird populations (Peitz 2015).

Birds, including waterbirds, are good indicators of changes in ecosystems (Stolen et al. 2005 and Butler et al. 2012), partly because they occur across a continuum of anthropogenic disturbances, species assemblages are predictive of these disturbance levels, birds are easily detected using standardized methods, and are well researched, providing a baseline against which change can be assessed (Bibby et al. 2000, Browder et al. 2002, Bryce et al. 2002, NABCI 2009). In addition, birds are well-liked by the public, the public can relate to concerns about bird communities, birding is a popular activity at most parks, and bird songs contribute to the natural soundscape.

Hardwood riparian forest and wetland habitats at CUVA support wintering, feeding, and breeding populations of both resident and migrating avian species. Due to relatively low levels of development and urbanization in CUVA, park habitats are especially valuable by providing relatively unfragmented patches of native wetlands and riparian hardwood forest that serve as a refuge within an altered and urbanized regional landscape. Changes in avian community composition and abundance in these habitats may indicate changes in the larger ecosystem. Habitat fragmentation and conversion of native habitats negatively impacts populations of some breeding and resident birds at CUVA, particularly specialist species that have evolved within stable environments (Keinath et al. 2017, Matthews et al. 2014, Devictor et al. 2008, La Sorte 2006). Avian community composition and diversity are expected to improve as riparian habitats are restored over time and recover from past disturbances (Johnson 2006, Boren et al. 1999).

<u>Threats and Stressors</u>

Threats to the CUVA bird community include the conversion of natural habitats through urban and commercial development, farming and livestock grazing, and altered hydrology and disturbance regimes locally, regionally and within the extent of bird migratory ranges (Bird Studies Canada 2008, Hansen and Gryskiewicz 2003). Threats result in habitat loss and fragmentation, habitat degradation, and polluted conditions (e.g., air and water pollution). In turn, these modifications disrupt ecological functions important to ecosystem integrity and to maintaining the community composition of species at CUVA comparable to that of the natural habitat of the region (Jorgensen and Müller 2000). Changes in land use are linked to ecological function by five mechanisms (Hansen and Gryskiewicz 2003):

- Land use activities reduce the functional size of a reserve, eliminating important ecosystem components lying outside the park boundary;
- Land use activities alter the flow of energy or materials across the landscape irrespective of the park's political boundary, disrupting the ecological processes dependent upon those flows both outside and inside the park and across its boundaries;
- Habitat conversion outside the park may eliminate unique habitats, such as seasonal habitats and migration corridors;
- The negative influences of land use activities may extend into the park and create edge effects; and
- Increased population density may directly impact parks through increased recreation and human disturbance.

Indicators and Measures

- Native species richness (S)
- Bird index of biotic integrity (IBI)
- Occurrence and status of bird species of conservation concern

4.9.2. Data and Methods

The Great Lakes states and southern Canada contain a sizable portion of the continental breeding distributions of many marsh, wetland, and riparian forest-associated bird species (Tacha and Braun 1994). As such, there are multiple ongoing long-term marsh bird monitoring programs active within the region. Examples include Bird Studies Canada's Prairie, Great Lakes, Quebec, and Maritime Marsh Monitoring Programs (Tozer 2013, Tozer 2016, Bird Studies Canada 2008); and the Great Lakes Coastal Wetland Monitoring Program (GLCWLC 2008). The Great Lakes Marsh Monitoring Program (GLMMP) is a bi-national, long-term monitoring program that coordinates the skills and dedication of hundreds of volunteer citizen scientists throughout the Great Lakes basin. The program was launched in 1995 with funding from Environment Canada, the U.S. Environmental Protection Agency, and the Great Lakes Protection Fund. The program aims to track changes in bird community composition and abundance in the Great Lakes coastal and inland marshes including at CUVA.

In 1995, the GLMMP began systematic surveys of breeding birds and their habitat at CUVA. Monitoring was conducted every year, except for 2003, at a subsample of six permanent fixed-distance point count sites where a trained surveyor standing at the survey point counted all birds seen or heard within a 100m radius of the point over a standardized 10 minute period (5 minutes of visual and auditory surveys, followed by five minutes of song broadcasting) (GLMMP 2008). Survey stations were separated by at least 300 meters to ensure independence among stations (i.e., minimize the change of double counting of birds during a visit) (Figure 4.9-1). Data from the six sample sites were used to determine the condition of the bird community at CUVA. One to six sites per year were sampled (Bird Studies Canada 2008). Cuyahoga Falls1 was the only site sampled prior to 2005.

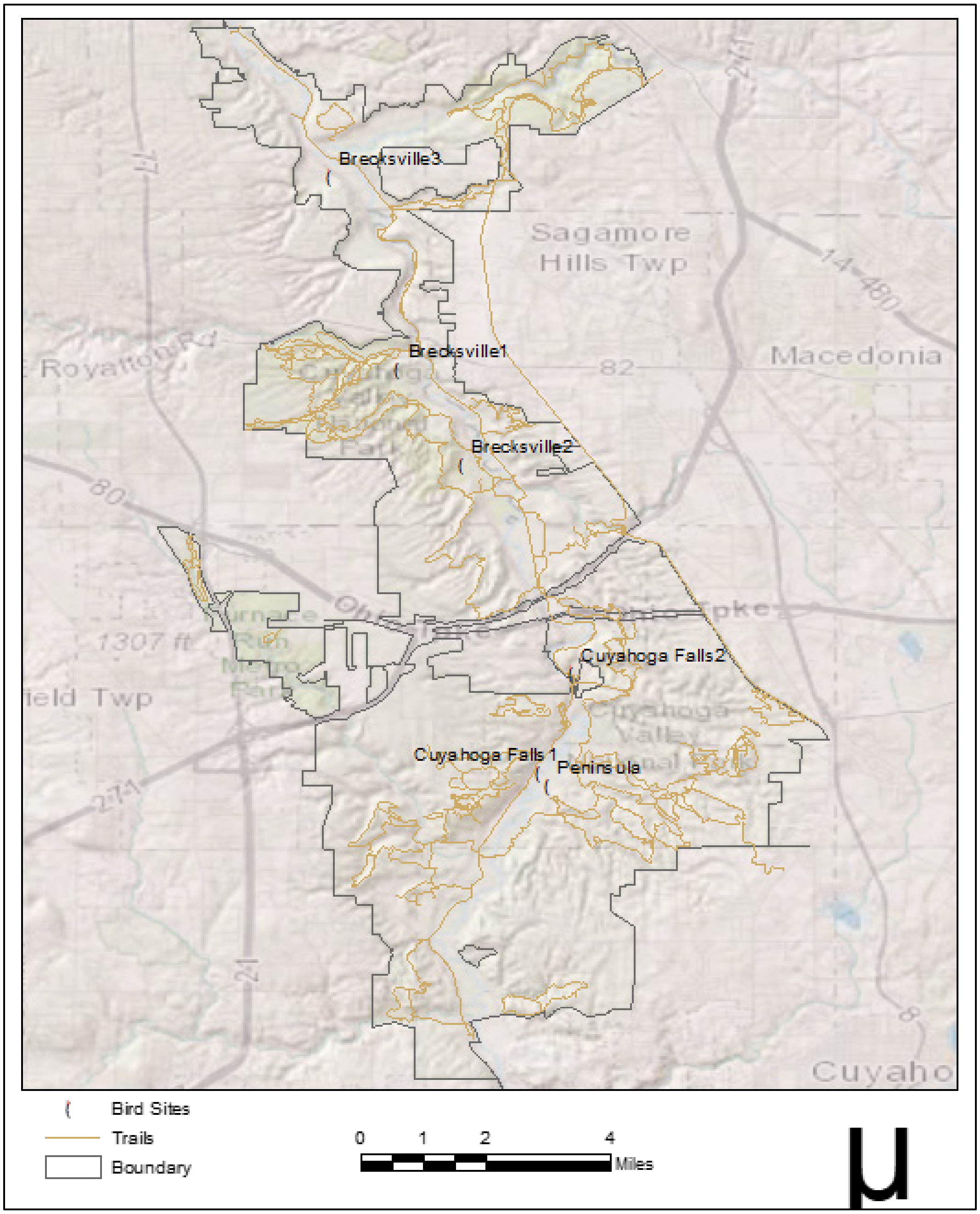


Figure 4.9-1. Bird plot locations on Cuyahoga Valley National Park, Ohio (plot locations provided by NPS; base map data from ESRI Streetmap).

To evaluate trends over time, we compared the occurrence of species detected during the initial 1995 survey to species detected during the 2016 survey. We compared native species richness between 1995 and 2016.

Bird Index of Biotic Integrity (IBI) values were calculated and compared between 1995 and 2016. The bird IBI is based on the methodology developed for bird communities of the Great Lakes and for the mid-Atlantic Highlands (Bird Studies Canada 2008, Crewe and Timmerman 2005, O'Connell et al

1998a). The bird IBI was modified from Bird Studies Canada (2008) to reflect the land-use and land-cover types of CUVA (e.g., marshland and riparian woodland). Specialist guilds included in the IBI tend to be associated with either extensive marshland or woodland cover. Therefore, higher IBI scores reflect bird communities associated with aspects of mature marshland and riparian woodland structure, function, and composition. For example, sites with higher bird IBI scores consist of a bird community with more marshland or interior forest-dependent species, invertebrate foragers, and single-brooded (i.e., specialists). The high IBI score sites would tend to have fewer omnivores, exotic/non-natives, nest predators/brood parasites, residents, and generalists. Guild selection considerations are discussed in Bird Studies Canada (2008), Crewe and Timmermans (2005), and O'Connell et al. (1998a).

To calculate the IBI score, species are first assigned to guilds (some species may be assigned to more than one guild, depending on their life history traits). The proportional species richness of each guild is then calculated by dividing the number of species detected within a specific guild by the total number of species detected. The next step in the bird IBI is to rank each category of proportional species richness for each guild on a scale of 5 (high integrity) to 0 (low integrity) (O'Connell et al. 1998a, 1998b, 2000). For specialist guilds, the highest-occurrence category is ranked a "5", the next highest a "4," etc. For generalist guilds, the ranking is reversed; a "5" is assigned to the lowest-occurrence category. Therefore, a site can receive a rank of "5" for a guild if the site supports the highest category of proportional species richness for a specialist guild or the lowest category of proportional species richness for a generalist guild. The final bird IBI score is then calculated by summing the rank for each guild's proportional species richness, across all guilds.

A community at the theoretical maximum high IBI score, or highest integrity, consists of a bird community with only specialist guilds and without any generalist guilds. The integrity represented by a particular IBI score is based upon a theoretical maximum community at CUVA receiving a marshland and riparian woodland bird IBI score of 91.5 and the theoretical minimum community, a score of 25, which corresponds to either only species from "specialist guilds" being detected or only species from "generalist guilds" being detected, respectively.

The biotic or ecological "condition" described by the bird IBI moves along a disturbance gradient from relatively intact, extensive, mature marshland or riparian woodland with high IBI scores to more disturbed, developed or urban marshland or riparian woodland with low IBI scores. The response guilds incorporated into the bird IBI are listed in Table 4.9-1.

Table 4.9-1. Bird species guilds used to calculate IBI scores (O'Connell et al. 1998a, 1998b).

Biotic Integrity Element	Guild Category	Response Guild	Number of Species in Guild	Guild Classification
Functional	Trophic	omnivore	34	generalist
	Insectivore Foraging Behavior	bark prober	5	specialist
	Insectivore Foraging Behavior	upper canopy forager	5	specialist
	Insectivore Foraging Behavior	lower canopy forager	11	specialist
	Insectivore Foraging Behavior	ground gleaner	3	specialist
	Insectivore Foraging Behavior	aerial screener	12	specialist
Compositional	Origin	exotic/non-native	4	generalist
	Migration Status	resident	25	generalist
	Migration Status	temperate migrant	24	generalist
	Number Of Broods	single-brooded	49	specialist
	Population Limiting	nest predator/brood parasite	5	generalist
Structural	Nest Placement	forest ground nester	2	specialist
	Nest Placement	marsh nester	8	specialist
	Nest Placement	lower canopy nester	1	specialist
	Nest Placement	upper canopy nester	25	specialist
	Nest Placement	open ground nester	8	specialist
	Nest Placement	shrub nester	16	generalist
	Primary Habitat	forest generalist	22	generalist
	Primary Habitat	interior forest obligate	6	specialist
	Primary Habitat	marsh/riparian obligate	23	specialist

Status of Species of Conservation Concern

Our intent was to determine which species that occur at CUVA are considered species of concern at either a national or local scale, and to assess the current status (occurrence) of those species at the park. This analysis was limited to those species that were either breeding at the park or that were residents. Those species occurring during migration only and incidental occurrences of species outside of their normal range were excluded.

To identify priority conservation species we used lists developed by Partners in Flight (PIF), a cooperative effort among federal, state and local government agencies that identifies and assesses species of conservation concern based on biological criteria including population size, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, and population trend (Panjabi et al. 2012). PIF assessments are conducted at both the national and regional scale. At the national scale, the PIF North American Landbird Conservation Plan identifies what are considered "Continental Watch List Species" and "Continental Stewardship Species" (Rosenberg et al. 2016). Conservation Watch List Species are considered by PIF to have the greatest need for conservation due to a combination of small and declining populations, limited distributions, and high threats throughout their ranges (Panjabi et al. 2012). Continental Stewardship species are defined as those species that have a significant percentage of their world breeding and/or nonbreeding population (i.e., breeding population for migratory birds) confined to a specific avifaunal biome. Avifaunal biomes are adjoining areas in North America that share similar avifaunas as identified through cluster analysis (Panjabi at al. 2012). We consulted the PIF Conservation Watch List and Stewardship species list to identify birds at CUVA that are a national conservation priority.

4.9.3. Reference Conditions

Little historical survey data exist for CUVA. Bird surveys using the point count method were conducted at CUVA in 1995 through 2004, but only at one site (Bird Studies Canada 2008). Four additional sampling sites were added at CUVA in 2005. One additional site was added in both 2008 and 2009 (Bird Studies Canada 2008). The initial survey year (1995) is used as a reference for comparison to current bird community quality. Maintaining or exceeding the level of biodiversity as defined by the initial (1995) native species richness, the initial quality of bird community composition as defined by the 1995 IBI score, and the number of species of concern recorded in 1995 are considered good condition. The condition of the resource is considered higher if more species of concern are observed. This implies that the populations of those species are increasing and/or they are using the park more. A condition rating framework for birds is shown in Table 4.9-2.

Threshold levels for bird IBI scores have not been rigorously defined, but O'Connell et al. (2000) established thresholds that include four categories of condition corresponding to the proportional species richness of each specialist guild and generalist guild. For the bird IBI score at CUVA these thresholds include the following categories: 1) excellent (highest integrity) – score of 81.1–91.5; 2) good (high integrity) – score of 63.1–81.0; 3) fair (medium integrity) – score of 39.5–63.0; and 4) poor (low-integrity rural and low-integrity urban) – score of 25.5–39.4. The condition classes were modified by combining the top two categories to determine the resource condition indicator scoring for the CUVA bird IBI (Table 4.9-2) using a three-tiered rating system.

Table 4.9-2. Resource condition rating framework for birds at Cuyahoga Valley National Park (framework developed by the authors based on previous work and professional opinion and O'Connell et al. 2000).

	Condition Status		
Indicator	**Resource is in Good Condition**	**Condition Warrants Moderate Concern**	**Condition Warrants Significant Concern**
Native Species Richness (S)	>85–100+ % of 1995 value[a] = > 24 spp.	70–85% of 1995 value = 19–24 spp.	<70% of 1995 value= <19 spp.
Index of Biotic Integrity	63.1–91.5	39.5–63.0	25.0–39.4
Bird Species of Conservation Concern	>85–100+ % of 1995 value (3 spp.)	70–85% of 1995 value	<70% of 1995 value

[a] Native species richness in 1995 at the Cuyahoga Falls1 site was 28 species.

4.9.4. Condition and Trend

Species Richness

A mean of 20.6 native species was recorded per sampling station in 2016, the most common species were the red-winged blackbird (*Poecile atricapillus*) and common grackle (*Picoides pubescens*). This total was less than 85% of the 28 native species recorded at the one site sampled, Cuyahoga Falls1, during the initial 1995 bird survey at CUVA (Table 4.9-3). Therefore, species richness at CUVA in 2016 warrants moderate concern (Table 4.9-2). The slope of the linear regression line for mean native bird species richness was negative, but not statistically significant, suggesting an unchanging trend in the richness of the bird community during the monitoring period. When multiple sites were monitored (2005 to 2016), the 90 percent confidence intervals for native species richness all overlap. Although the precision of the estimates is relatively poor for most years, this may suggest that the number of native bird species observed has remained relatively unchanged since 2005, when multiple sites were first monitored at CUVA (Figure 4.9-2).

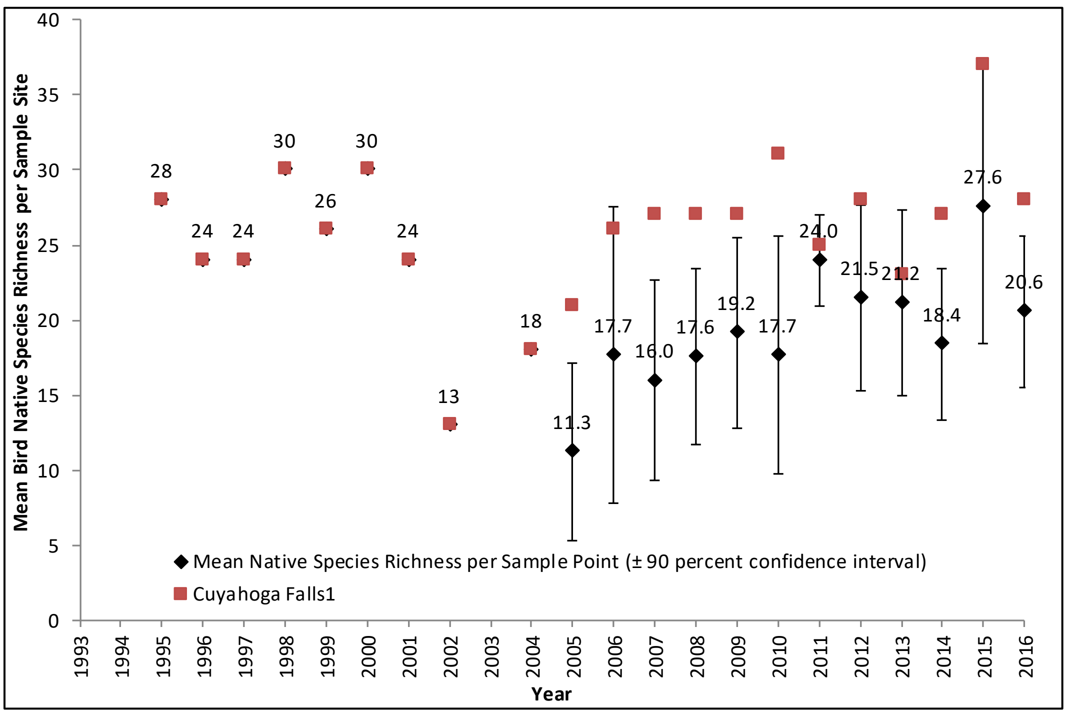


Figure 4.9-2. Means and 90 percent confidence intervals for native bird species richness at CUVA from 1995 to 2016. During 1995 to 2004 only the Cuyahoga Falls1 site was sampled (n=1)(data from Great Lakes Marsh Monitoring Program).

Index of Biotic Integrity

The 2016 bird IBI score of 53.5 indicates that composition of the bird community at CUVA warrants moderate compared to the reference year of 1995 (Table 4.9-2). The slope of the linear regression line for the bird IBI scores was negative, but not statistically significant, suggesting an unchanging trend in the IBI scores at CUVA. The variability within the data appears high, suggesting that the sampling design may not be sensitive to detecting changes and may have low precision. There is considerable overlap in the 90 percent confidence intervals for the scores (Figure 4.9-3).

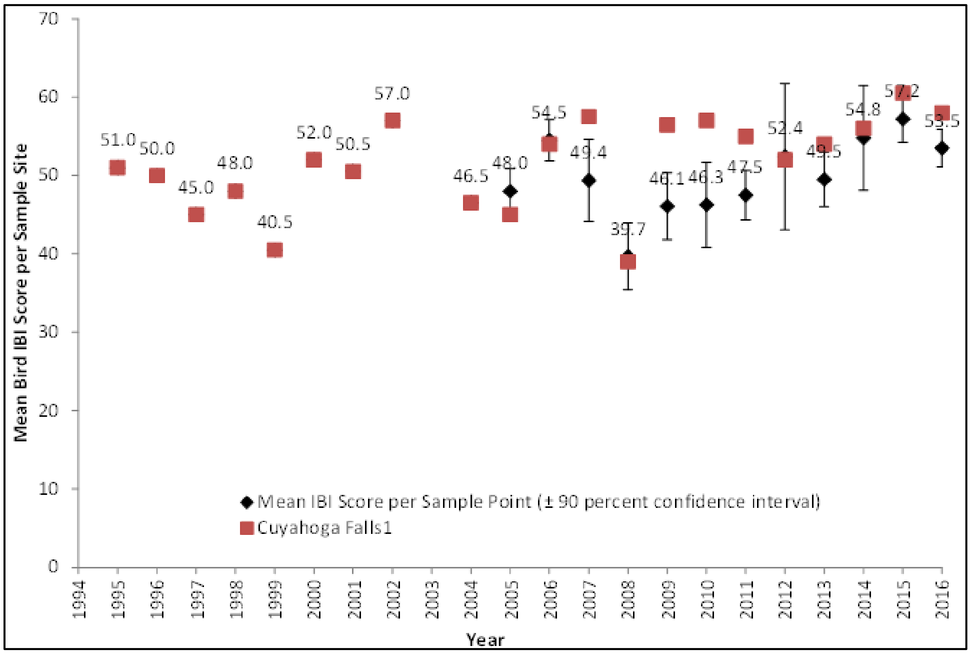


Figure 4.9-3. Means and 90% confidence intervals for bird IBI scores at CUVA from 1995 to 2016. Values for Cuyahoga Falls1 site are shown for the entire period of monitoring (1995–2016)(data source Great Lakes Marsh Monitoring Program).

Species of Concern

A mean of 4.2 species of concern per site was recorded during the 2016 Great Lakes Marsh Monitoring program (Rosenberg et al. 2016, Robertson and Rosenberg 2003), which was 1.2 more than the 3 species of concern reported in 1995 (Table 4.9-3). Three riparian obligate species that are of conservation concern were recorded at CUVA in 2016: the marsh wren (*Cistothorus palustris*), Virginia rail (*Rallus limicola*), and willow flycatcher (*Empidonax traillii*). This was more than the one riparian obligate species of concern recorded in 1995, the prothonotary warbler (*Protonotaria citrea*). The most common species of concern recorded at CUVA in 2016 was the common grackle (*Quiscalus quiscula*). Most of the species of concern increased in number from the 1995 survey to the 2016 survey (Table 4.9-3).

The slope of the linear regression line for the bird species of concern was negative, but not statistically significant, suggesting a stable trend in the number of bird species of concern present at CUVA. For the years when multiple sites were monitored (2005 to 2016), the 90 percent confidence intervals for the number of species of concern all overlap. This also suggests the number of bird species of concern has remained stable since 2005, when multiple sites were first monitored at CUVA (Figure 4.9-4). In 2016, bird species of concern at CUVA averaged 4.2 per sample site, more than the management target of ≥ 3, the score recorded in 1995 when monitoring was initiated at CUVA, indicating good condition.

Table 4.9-3. Bird species recorded in 2016 and 1995 at survey stations on CUVA (Great Lakes Marsh Monitoring Program).

Common name	Species name	AOU code	#Detected 2016	#Detected 1995
American Goldfinch	*Agelaius phoeniceus*	AMGO	3	2
American Robin	*Aix sponsa*	AMRO	4	1
Baltimore Oriole	*Anas platyrhynchos*	BANS	4	0
Bank Swallow[a]	***Archilochus colubris***	**BAOR**	**2**	**3**
Barn Swallow	*Ardea herodias*	BARS	5	0
Belted Kingfisher	*Bombycilla cedrorum*	BCCH	2	2
Black-capped Chickadee	*Branta canadensis*	BEKI	1	0
Blue Jay	*Buteo jamaicensis*	BGGN	1	1
Blue-gray Gnatcatcher	*Butorides virescens*	BLJA	1	1
Canada Goose	*Cardinalis*	CAGO	1	0
Cedar Waxwing	*Cathartes aura*	CEDW	3	1
Chimney Swift[a,b]	***Catharus fuscescens***	**CHSW**	**2**	**0**
Common Grackle[a]	***Chaetura pelagica***	**COGR**	**12**	**0**
Common Yellowthroat	*Charadrius vociferus*	COYE	4	1
Downy Woodpecker	*Cistothorus palustris*	DOWO	2	0
Eastern Kingbird	*Coccyzus americanus*	EAKI	2	3
Eastern Wood-Pewee	*Colaptes auratus*	EAWP	2	0
European Starling	*Contopus virens*	EUST	5	2
Gray Catbird	*Cyanocitta cristata*	GBHE	3	1
Great Blue Heron	*Dryocopus pileatus*	GCFL	8	1
Great Crested Flycatcher	*Dumetella carolinensis*	GRCA	3	1
Green Heron	*Empidonax traillii*	GRHE	4	0
House Wren	*Geothlypis trichas*	HOWR	0	1
Killdeer	*Hirundo rustica*	KILL	1	0
Least Bittern	*Icterus galbula*	LEBI	1	0
Mallard	*Ixobrychus exilis*	MALL	1	1
Marsh Wren[b]	*Larus delawarensis*	MAWR	3	0
Mourning Dove	*Megaceryle alcyon*	MODO	7	0
Northern Cardinal	*Melanerpes carolinus*	NOCA	6	1
Northern Flicker	*Melanerpes erythrocephalus*	NOFL	2	2
Northern Rough-winged Swallow	*Melospiza georgiana*	NRWS	0	1

[a] Partners in Flight species considered of continental importance or common birds in steep decline (also in bold).

[b] Partners in Flight Priority Species for Physiographic Area 24 (also highlighted): The Allegheny Plateau. (Note: species that are both bolded and highlighted (table notes a and b) are listed as priorities both continentally and in Physiographic Area 24)

Table 4.9-3 (continued). Bird species recorded in 2016 and 1995 at survey stations on CUVA (Great Lakes Marsh Monitoring Program).

Common name	Species name	AOU code	#Detected 2016	#Detected 1995
Pileated Woodpecker	*Melospiza melodia*	PIWO	2	0
Prothonotary Warbler[a]	***Myiarchus crinitus***	**PROW**	**0**	**1**
Red-bellied Woodpecker	*Pheucticus ludovicianus*	RBGR	4	0
Red-headed Woodpecker[a, b]	***Picoides pubescens***	**RBGU**	**1**	**0**
Red-tailed Hawk	*Piranga olivacea*	RBWO	0	1
Red-winged Blackbid	*Poecile atricapillus*	RCKI	15	1
Ring-billed Gull	*Polioptila caerulea*	RHWO	2	0
Rose-breasted Grosbeak[b]	*Protonotaria citrea*	RTHA	1	1
Ruby-crowned Kinglet	*Quiscalus quiscula*	RTHU	0	0
Ruby-throated Hummingbird	*Rallus limicola*	RWBL	1	3
Scarlet Tanager[b]	*Regulus calendula*	SCTA	1	0
Song Sparrow	*Riparia*	SOSP	3	4
Swamp Sparrow	*Setophaga petechia*	SWSP	6	0
Tree Swallow	*Sitta carolinensis*	TRES	8	2
Turkey Vulture	*Spinus tristis*	TUVU	2	1
Veery	*Stelgidopteryx serripennis*	VEER	1	0
Virginia Rail[b]	*Sturnus vulgaris*	VIRA	2	0
Warbling Vireo	*Tachycineta bicolor*	WAVI	6	3
White-breasted Nuthatch	*Troglodytes aedon*	WBNU	1	0
Willow Flycatcher[b]	*Turdus migratorius*	WIFL	2	0
Wood Duck	*Tyrannus*	WODU	6	1
Yellow Warbler	*Vireo gilvus*	YBCU	7	0
Yellow-billed Cuckoo[a]	***Zenaida macroura***	**AMGO**	**2**	**0**

[a] Bolded names are those Partners in Flight species considered of continental importance or common birds in steep decline.

[b] Highlighted names are those Partners in Flight Priority Species for Physiographic Area 24: The Allegheny Plateau. (Note: species that are both bolded and highlighted are listed as priorities both continentally and in Physiographic Area 24)

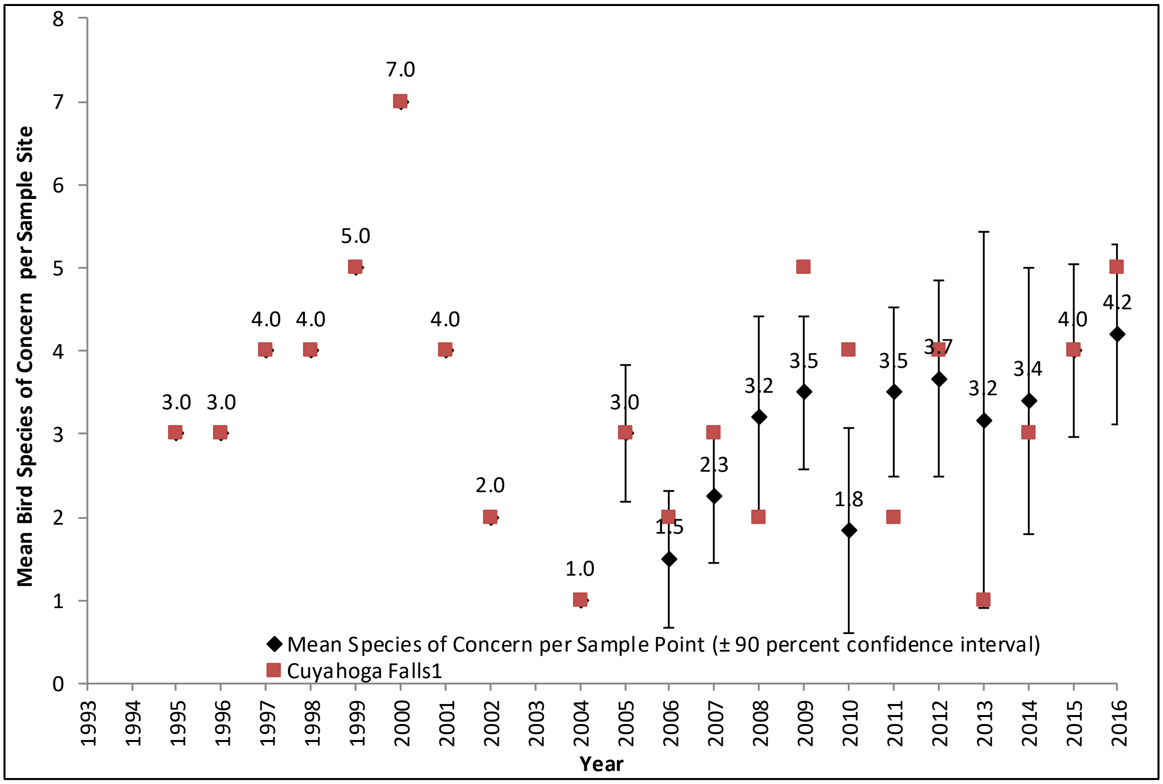


Figure 4.9-4. Means and 90 percent confidence intervals for number of bird species of concern at CUVA from 1995 to 2016. From 1995 to 2004 only the Cuyahoga Falls1 site was sampled (n=1)(data source Great Lakes Marsh Monitoring Program).

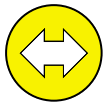
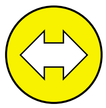
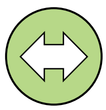
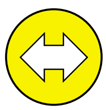
<u>Overall Condition and Trend</u>

The values for the metrics of native species richness, the bird IBI, and the number of species of concern present in 2016 indicate that the condition of the bird communities at CUVA warrants moderate concern, with a number of obligate marshland birds and a community structure that is representative of a moderately disturbed landscape (Table 4.9-4). Results for the survey period suggest an unchanging trend in bird community diversity and structure at CUVA. The overall condition of the bird community warrants moderate concern with an unchanging trend; confidence in the assessment is medium.

4.9.5. Uncertainty and Data Gaps

Confidence in this assessment was medium as is the confidence in the trend. The key uncertainty related to the assessment of the bird community at CUVA is the small sample sizes, which result in low precision of sample estimates. Comprehensive data collected over an ample number of sample sites is needed to assess the natural temporal fluctuation of the condition indicators used in this assessment and to assure the accuracy of the assessment (Denes et al. 2015). We suggest that the park evaluate the statistical strength of the existing design using historical data. It's possible that changes are occurring and are not being captured by the sample data. Non-sampling errors associated with the use of multiple volunteers over long time periods could also introduce error, including bias associated with varying detection capabilities of the observers, which can reduce the ability to identify statistically significant trends in the data (Dornelas et al. 2012).

Table 4.9-4. Condition and trend summary for birds at Cuyahoga Valley National Park.

Indicator	Condition Status/Trend	Rationale
Native Species Richness (S)		Mean riparian marsh and bottomland forest bird species richness per sample site fluctuated between 11.3 and 30 species from 1995 to 2016, with mean richness equaling 20.6 in 2016 (warrants moderate concern).
Bird Index of Biotic Integrity		In 2016, mean riparian marsh and bottomland forest bird IBI score per sample site was 53.5 (warrants moderate concern). Analysis of the bird IBI scores indicates an unchanging trend in the biotic integrity of the bird community between 1995 and 2016.
Species of Conservation Concern		The mean number of bird species of concern per sample site fluctuated between 1.0 and 7.0 species from 1995 to 2016 with 4.2 species of concern present in 2016 (good condition). Analysis of the bird monitoring data indicates an unchanging trend in the number of species of concern present between 1995 and 2016.
Riparian Birds overall		**Condition warrants moderate concern with an unchanging trend. Confidence in the assessment is medium.**

Another potential factor affecting the quality of the data is the probability that a bird that is present during the time the point count is occurring is detected. The protocols used for monitoring birds by the GLMMP rely on a 10-minute count interval, which is extensive enough to improve the probability of detecting a species, but because points are surveyed only once per year, there is always the chance that rare or less vocal species go undetected. This can be a problem when calculating the index of biotic integrity, which is calculated based on the number of species within different guilds.

4.9.6. Sources of Expertise

Bird Studies Canada (http://www.birdscanada.org/) is the primary source of expertise for long-term monitoring data at CUVA and data for the park is accessible through their site at NatureCounts (https://www.birdscanada.org/birdmon/default/main.jsp).

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4.10. Fish

4.10.1. Background and Importance

The National Park Service protects, preserves, and manages biological resources and related ecosystem processes in the national park system including aquatic resources. Fish communities within the streams and rivers of the park units are components of these aquatic systems and are important components of the Cuyahoga River including within CUVA (NPS 2013, CRR 2015). North American freshwater fish have been in decline since the early 20th century (Jelks et al. 2008, Parks et al 2014). This decline has been caused by multiple factors including habitat destruction and degradation (Jelks et al. 2008), habitat fragmentation caused by reservoir construction, reduced discharge caused by groundwater withdrawal, and invasion by non-native fishes (Gido et al. 2010). The federal government formally recognized the decline of stream and river systems in the United States in the 1990s, and in 2008 actions were initiated by the NPS to confront the loss of fish in these systems (USEPA 1990, USEPA 1995, Dodd et al 2008). The NPS recommends an approach to managing this critical resource that focuses on monitoring the fish community to understand community condition and trends.

Fish populations are excellent indicators of water and habitat quality because specific species are intolerant of chemical pollutants or habitat changes (Barbour et al. 1999, Grabarkiewicz and Davis 2008, Petersen et al. 2008, Kanno et al. 2010). For this reason, fish community composition offers an indication of stream environmental health. In addition, fish offer recreational opportunities to the public making their status a valuable interpretive topic for park visitors.

NPS lands provide some of the least impacted stream habitat remaining in the Midwest and streams at CUVA offer quality habitat for native fishes (Williams 2009). Because of the rarity of undisturbed non-urban and non-agricultural landscapes in the region, CUVA is especially valuable by providing relatively undisturbed stream and river habitat critical for sustaining native fishes within a highly altered landscape (Dodd et al. 2008). The habitat fragmentation and conversion of native vegetation to agricultural and urban landscapes occurring outside the park will negatively impact populations of some fish species resident to CUVA, particularly intolerant species that have evolved within stable environments (Knopf and Samson 1996, Gido et al 2010). Fish community composition and diversity should improve with restoration projects, such as native habitat restoration, reconnection of the floodplain to the river corridor, dam removal, barrier and impoundment bypass and removal, improved and comprehensive sewage treatment, or flow modifications both within CUVA and the surrounding landscape (Tetra Tech 2017).

The diversity of the fish community at CUVA is greatly influenced by natural flows within the Cuyahoga River. Infamously known as “the river that burned”, a large fire on the Cuyahoga River in June 1969 prompted the United States government to begin drafting legislation to correct the country’s air and water quality problems. While the river still has water quality issues, as a whole, the Cuyahoga River’s water quality has significantly improved with ongoing restoration efforts designed to meet the goals of the *Cuyahoga River Area of Concern Restoration Plan* (formerly the RAP – *Remedial Action Plan*) (Ohio EPA 2014). Alterations to the quantity and the temporal patterns of river flow regimes resulting from damming can negatively affect fish abundance, biomass, diversity and the guilds represented within a fish community (Anderson et al. 2006, Macnaughton et al. 2017).

The Canal Diversion Dam (i.e., Brecksville Dam) located within CUVA is one of only several major dams/diversions remaining on the Cuyahoga River. Upstream mainstem dams include Gorge Dam and Lake Rockwell Dam. The OHIO EPA concluded that the Canal Diversion Dam has impacted the aquatic community of the Cuyahoga River, causing the river to fail the goals of both the Clean Water Act and Ohio's Water Quality Standards (WQS), placing it on the Greats Lakes Areas of Concern List (Ohio EPA 2017). In an attempt to improve the river's aquatic community and assist in its removal from the Area of Concern List the Ohio EPA, CUVA, Ohio Department of Natural Resources, and US Army Corps of Engineers has proposed the full removal of the Canal Diversion Dam (Ohio EPA 2017). The long-term benefits to the river associated with dam removal are expected to include habitat improvement for fish and sensitive species including darters (*Etheostoma* spp.), sturgeon (*Acipenser* spp.), and muskellunge (*Esox masquinongy*); free-flowing fish passage for native fish and increasing diversity; the potential return of riverine mussel species; and full attainment of WQS for aquatic life use (Ohio EPA 2017). One detriment of dam removal is the consequent enhancement of fish passage allowing for the migration of non-native aquatic species including sea lamprey (*Petromyzon marinus*), gobies (*Apollonia melanostomus*), carp (*Cyprinus carpio*), and zebra mussels (*Dreissena polymorpha*) up river from Lake Erie and into CUVA. These species currently are not found above Brecksville Dam (Ohio EPA 2017).

<u>Threats and Stressors</u>

Primary threats to the fish community at CUVA are habitat destruction, degradation, modification, fragmentation and nonnative fish introductions (CRR 2015 and Tetra Tech 2017). Development and agriculture in the surrounding landscape have resulted in siltation, reduced water quality, tributary impoundment, stream channelization, instream gravel mining, and changes in stream hydrology (CRR 2015). The combined and interacting effects of these influences have resulted in population declines and range reduction of freshwater fish not only at CUVA, but also in the area surrounding the park. The NPS segment of the Cuyahoga River forms a critical link between the lower Cuyahoga/Lake Erie and the river upstream from the park. The first five miles of the river from Lake Erie consists of an engineered shipping channel that begins near the ArcelorMittal steel mill just south of the Interstate 490 Bridge.

Protection of freshwater biodiversity is difficult because it is influenced by the upstream drainage network, the surrounding land, and activity in the riparian zone (Dudgeon et al. 2006). The modifications to the surrounding landscape disrupt ecological functions important to ecosystem integrity and important to maintaining the community and composition of species at CUVA comparable to that of the natural habitat of the region (Jorgensen and Müller 2000). Consequently, the ecological functioning of CUVA depends upon maintaining the natural systems outside the park's boundaries.

<u>Indicators and Measures</u>

- Native species richness (S)

- Fish index of biotic integrity (IBI)
- Occurrence and status of fish species of conservation concern

4.10.2. Data and Methods

In 1984, the Ohio Environmental Protection Agency implemented long-term monitoring of fish in the Cuyahoga River including within CUVA (Ohio EPA 1999). Fish monitoring is being conducted as part of the remedial action plan for the Cuyahoga River Area of Concern. The plan's purpose is to develop criteria for the river's restoration, implement remedial measures, monitor the effectiveness of such measures, and confirm that restoration is achieved (CRR 2015). The purpose of the fish monitoring effort is to determine the status and long-term trends in fish community composition and abundance, and to correlate this community data with water quality and habitat conditions. Monitoring results support the development of prioritized management actions to improve the environmental quality of the river both for fish and the public (Tetra Tech 2017). The data we analyzed are from 10 stations on the Cuyahoga River within CUVA that were sampled in 14 different years between 1984 and 2017 (Figure 4.10-1). The number of river stations sampled per year varied, ranging from eight (1984, 1985, 1987, 1988, and 2008) to one (1991 and 2009 through 2011). Because the number of sites sampled varied over the years, the mean values of the indicators per sample reach were used to assess condition and trend in the fish community at CUVA. Methods used to sample the fish community are contained in Biological Criteria for the Protection of Aquatic Life: Volume III, Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities (Ohio EPA 1987, 2015).

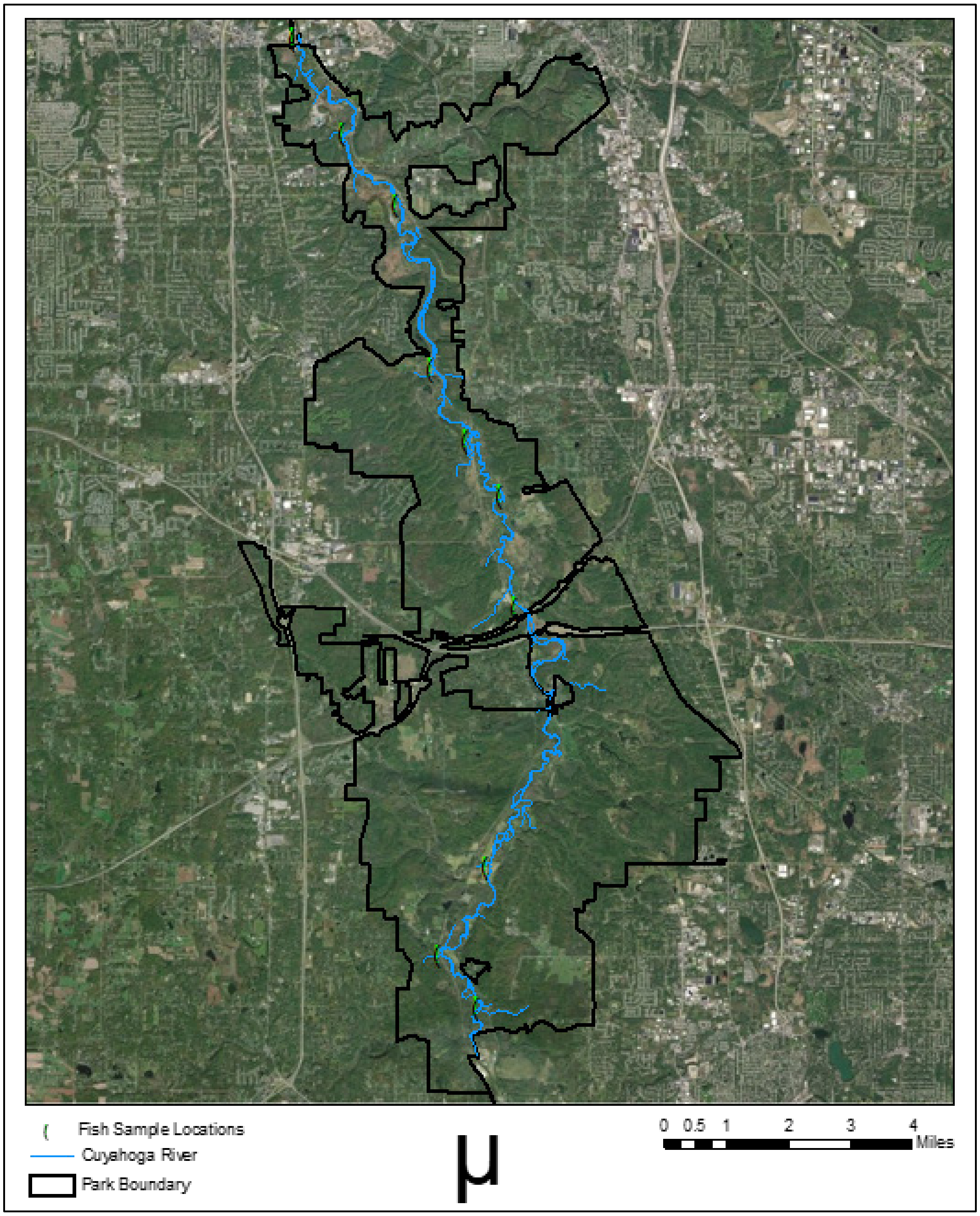

Figure 4.10-1. Location of fish sample stations on Cuyahoga Valley National Park, Ohio (data sources: NPS, ESRI background imagery).

To evaluate trends over time, we compared the number of native species detected in 1984 to those detected during the 2017 survey.

Fish Index of Biotic Integrity (IBI) values were calculated and compared between the years 1984 and 2017. The fish IBI is based on methodology developed for fish communities of Ohio (Ohio EPA 1987, 2006, 2015). Specialist guilds included in the IBI tend to be associated with more pristine and less degraded freshwater habitats. Therefore, higher IBI scores reflect fish communities associated with habitats where water quality is high and with fewer land-use changes in the upland affecting instream conditions. For example, sites with higher fish IBI scores consist of a fish community with more total species, round-bodied suckers, sunfish species, sucker species, intolerant species, insectivores; carnivores, and lithophilic spawning species (i.e. specialist guilds), but with fewer omnivores, tolerant species and with less occurrence of anomalies (i.e. generalist guilds). An extensive discussion for why these guilds are chosen over others can be found in Dauwalter et al. (2003).

The biotic or ecological "condition" described by the fish IBI moves along a disturbance gradient from a relatively intact, pristine, high water quality stream with high IBI scores to a more disturbed, developed or urban landscape with lower water quality and lower IBI scores. Classification of the fish species observed at CUVA into trophic and reproductive behavior guilds and assessment of species tolerance followed the classifications of the Ohio EPA (1987). The response guilds incorporated into the fish IBI are listed in Table 4.10-1.

Table 4.10-1. Fish species guilds used to calculate the IBI score (Ohio EPA 1987).

Biotic Integrity Element	Guild Category	Response Guild	Number of Species in Guild[a]	Guild Classification
Functional	Species richness	total number of native fish species	61	specialist
	Fish abundance	total number of individuals in sample	na	specialist
	Species composition	proportion of individuals as round-bodied suckers	5	specialist
	Species composition	number of sunfish species	10	specialist
	Species composition	number of sucker species	11	specialist
	Trophic composition	proportion of individuals as omnivores	8	generalist
	Trophic composition	proportion of individuals as insectivores	39	specialist
	Trophic composition	proportion of individuals as top carnivore	10	specialist
Tolerance – Intolerance	Intolerant species	Total number of intolerant species	14	specialist
	Tolerant species	Proportion of tolerant species	4	generalist
Physical Condition	DELT anomalies	Proportion of individuals with deformities, eroded fins, lesions, and tumors	na	generalist
Structural	Reproductive Behavior	Total number of lithophilic spawning species	13	specialist

[a] na = not applicable.

A broader fish conservation context was evaluated by examining the native fish community to determine which species that occur at CUVA are considered species of conservation concern either nationally or in Ohio, and to assess the current status (occurrence) of those species at the Park.

To identify fish species that are of conservation priority we used species listed as either endangered or threatened by the U. S. Fish and Wildlife Service (USFWS) under the Endangered Species Act; U.

S. Forest Service (USFS) and Bureau of Land Management (BLM) sensitive species lists; NatureServe G1 to G3 and S1 ranked species; and State lists of endangered, threatened and special concern species.

Most states have endangered species statutes or acts, which consider the species risk of extinction within the state and list at risk species as either endangered, threatened, or special concern. Listed species are then protected by regulations enforced by state governments preventing activities that negatively impact listed species populations and their critical habitat. Including fish listed by the Ohio Endangered Species Act in the condition assessment for CUVA recognizes that some species may be declining dramatically at the local scale, even though they are not of high concern nationally.

4.10.3. Reference Conditions

Little historic survey data exist for CUVA. Fish surveys conducted on the Cuyahoga River including 10 stations within CUVA by the Ohio EPA were initiated in 1984 (Ohio EPA 1999). Fish reference condition for CUVA uses the initial 1984 Ohio EPA fish survey results as a baseline. Maintaining or exceeding the level of biodiversity as defined by initial calculation of native species richness (as an index of diversity) and the initial quality of fish community composition as defined by the initial IBI score are considered good condition. A rating system for departure from good condition is shown in Table 4.10-2.

The fish IBI score reflects a disturbance gradient from relatively intact and high quality stream ecosystem with high IBI scores to more disturbed, developed or urban stream ecosystem with low IBI scores. To calculate the IBI score, species are first assigned to guilds based on taxonomic composition, trophic composition, reproductive composition, environmental tolerance and fish condition (some species may be assigned to more than one guild, depending on their life history traits). The proportional richness of each guild is then calculated by dividing the number of individuals or species detected within a specific guild by the total number of individuals or species detected.

The next step in the fish IBI is to assign scores to each of the 12 IBI metrics for each station that was sampled in the year being evaluated (Table 4.10-1). Scoring of the data for each of the 12 metrics is based on analyses conducted by the Ohio EPA on fish community data at over 300 reference sites from throughout Ohio (Ohio EPA 1987). The scoring criteria used can be found in Table 4-6 of the report by the Ohio EPA (1987). Once scores have been assigned to each metric the IBI score for an individual site and year is calculated by summing the scores across all 12 metrics:

$$\mathrm{MSS_i} = \sum_{i=1}^{12} MRi \ ,$$

where $\mathrm{MSS_i}$ = metric score for *i*th sample station and MR = raw metric score assigned from Table 4-6 Ohio EPA (1987) to the *i*th of the 12 metrics. The final IBI score for an individual sample year is determined by calculating the mean IBI score across all of the stations sampled in that particular year:

$$\mathrm{IBI} = \frac{\sum_{i}^{N} MSSi}{N} \ ,$$

where IBI = IBI score, MSS_i = the summed score for the *i*th station and N = the number of stations sampled in that year. A community at the theoretical maximum high IBI score, or highest integrity, consists of a fish community with only specialist guilds and without any generalist guilds.

Threshold levels for fish IBI scores have not been rigorously defined, but the Ohio EPA (1987, 2006) established thresholds that include seven categories of condition. For the fish IBI score at CUVA we combined the three highest, the middle two, and the two lowest Ohio EPA categories to create the following three assessment categories: 1) good (good integrity) – score of 40.0–60; 2) marginally good (fair-integrity) – score of 26.0–39; 3) fair (poor integrity) – score of 12–35.

We also compared the candidate list of species of concern to the actual list of species observed at CUVA during the 2017 survey. We used the number of species of concern recorded in the initial survey year of 1984 as the reference condition for comparison. The condition of the resource is considered higher if more species of concern are observed. This implies that the populations of those species are increasing and/or they are using the park more.

Table 4-10-2. Resource condition rating framework for fish at Cuyahoga Valley National Park (IBI thresholds from Ohio EPA 1987).

Indicator	Condition Status		
	Resource is in Good Condition	**Warrants Moderate Concern**	**Warrants Significant Concern**
Native Species Richness (S)	>85–100+ % of 1984 value	70–85% of 1984 value	<70% of 1984 value
Index of Biotic Integrity	40.0–60	26–39	12.0–25
Fish Species of Conservation Concern (presence)	85–100+ % of 1984 value	70–85% of 1984 value	<70% of 1984 value

4.10.4. Condition and Trend

Species Richness

A total of 44 native fish species were recorded at stream sampling stations in 2017; the most common species was the northern hog sucker (*Hypentelium nigricans*). This total is greater than the 26 species recorded during the 1984 fish survey at CUVA (Table 4.10-3). The spotfin shiner (*Cyprinella spiloptera*) and white sucker (*Catostomus commersonii*) were also quite common in the 2017 fish sample (Table 4.10-3). Mean native species richness per sample reach was 26 in 2017, significantly greater than the 9 species recorded in 1984 (Figure 4.10-2). There were no federally-listed, proposed or sensitive fish species or state-listed fish species recorded at CUVA in either 1984 or 2017.

The slope of the linear regression line for mean native fish species richness per sample station was positive and statistically significant ($r^2 = 0.67$, $p = 0.0004$), suggesting an improving trend in the richness of the fish community at CUVA over time. The 90 percent confidence intervals for native species richness for the years 1984 to 2017 overlap some, suggesting more stability in native fish species richness since the late 1980s (Figure 4.10-2). The mean native fish species per sample station recorded at CUVA in 2017 was 26 species, nearly three times the 1984 value and much greater than the management target of 85% of 9 (1984 benchmark) or 8 species. Results indicate the resource is in good condition (Table 4.10-2).

Table 4.10-3. Fish species abundance recorded in 2017 and 1984 at Cuyahoga River sample stations within Cuyahoga Valley National Park (data obtained from Ohio EPA).

Common Name	Species Name	Number Recorded		NatureServe Rank
		2017	1984	
Black Crappie	*Ameiurus melas*	3	3	G5S5
Bluegill Sunfish	*Pomoxis nigromaculatus*	241	38	G5S5
Bluntnose Minnow	*Pimephales notatus*	253	23	G5S5
Bowfin	*Amia calva*	0	1	G5S4
Brown Bullhead	*Amia calva*	0	20	G5S5
Central Mudminnow	*Umbra limi*	2	0	G5S4
Central Stoneroller	*Campostoma anomalum*	68	10	G5S5
Channel Catfish	*Ictalurus punctatus*	37	0	G5S5
Common Carp	*Cyprinus carpio*	39	110	G5SNA
Common Shiner	*Luxilus cornutus*	294	8	G5S4
Creek Chub	*Semotilus atromaculatus*	20	22	G5S5
Fantail Darter	*Etheostoma brevispinum*	3	0	G4
Fathead Minnow	*Pimephales promelas*	4	3	G5
Flathead Catfish	*Pylodictis olivaris*	9	0	G5S5
Freshwater Drum	*Aplodinotus grunniens*	5	5	G5S4
Gizzard Shad	*Dorosoma cepedianum*	88	252	G5S5
Golden Redhorse	*Moxostoma erythrurum*	24	0	G5S5
Goldfish	*Carassius auratus*	2	3	G5
Green Sunfish	*Lepomis cyanellus*	168	49	G5S5
Greenside Darter	*Etheostoma blennioides*	90	0	G5S5
Hybrid x Sunfish	–	8	0	na
Johnny Darter	*Etheostoma nigrum*	4	1	G5S5
Largemouth Bass	*Micropterus salmoides*	18	8	G5S5
Logperch	*Percina caprodes*	2	0	G5S5
Northern Hog Sucker	*Hypentelium nigricans*	775	0	G5S5
Northern Pike	*Esox lucius*	1	0	G5S4
Pumpkinseed Sunfish	*Lepomis gibbosus*	29	4	G5S5
Quillback	*Carpiodes cyprinus*	7	0	G5S5
Rainbow Darter	*Etheostoma caeruleum*	21	0	G5S5
River Chub	*Nocomis micropogon*	4	0	G5S4
Rock Bass	*Ambloplites rupestris*	9	0	G5S5
Round Goby	*Neogobius melanostomus*	10	0	G5SNA

Table 4.10-3 (continued). Fish species abundance recorded in 2017 and 1984 at Cuyahoga River sample stations within Cuyahoga Valley National Park (data obtained from Ohio EPA).

Common Name	Species Name	Number Recorded		NatureServe Rank
		2017	**1984**	
Sand Shiner	*Notropis stramineus*	94	1	G5S5
Shorthead Redhorse	*Moxostoma macrolepidotum*	42	0	G5S4
Silver Redhorse	*Moxostoma anisurum*	3	0	G5S5
Silverjaw Minnow	*Notropis buccatus*	36	0	G5S5
Smallmouth Bass	*Micropterus dolomieu*	155	0	G5S5
Spotfin Shiner	*Cyprinella spiloptera*	529	0	G5S5
Stonecat Madtom	*Noturus flavus*	1	0	G5S5
Walleye	*Sander vitreus*	3	0	G5S5
Warmouth Sunfish	*Lepomis gulosus*	0	1	G5S4
Western Blacknose Dace	*Rhinichthys obtusus*	5	0	G5S5
White Bass	*Morone chrysops*	1	2	G5S5
White Crappie	*Pomoxis annularis*	0	10	G5S5
White Perch	*Morone americana*	98	8	G5
White Sucker	*Catostomus commersonii*	623	83	G5S5
Yellow Bullhead	*Ameiurus natalis*	75	0	G5S5
Yellow Perch	*Perca flavescens*	9	0	G5S5

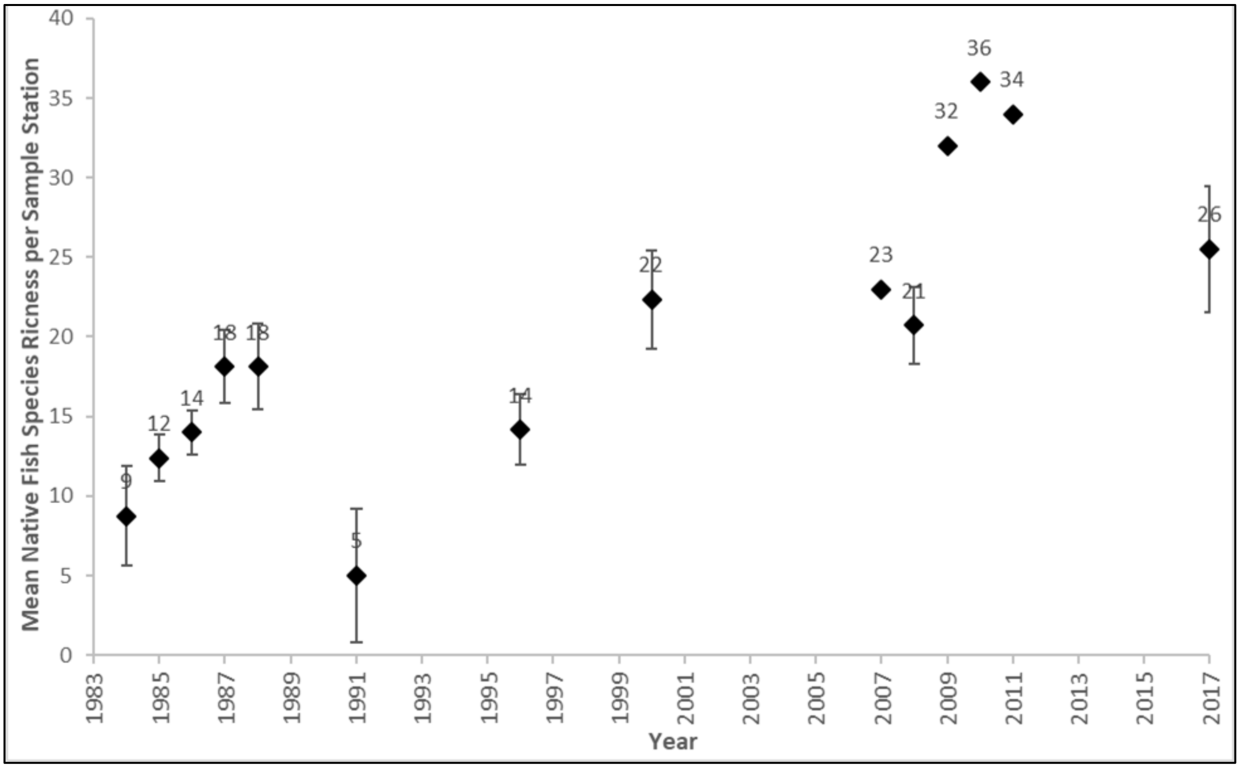

Figure 4.10-2. Means and 90 percent confidence intervals for native fish species richness per sample reach at Cuyahoga Valley National Park from 2001 to 2017 (data obtained from Ohio EPA).

<u>Index of Biotic Integrity</u>

The mean fish IBI score per sample station in 2017 was 39 compared to the 1984 score of 21. This IBI score indicates that composition of the fish community at CUVA in 2017 warrants moderate concern (Table 4.10-2). The slope of the linear regression line for the fish IBI score was positive and statistically significant ($r^2 = 0.75$, $p < 0.001$), indicating the biotic integrity of the fish community between 1984 and 2017 was improving. The 90 percent confidence intervals for the scores from 2000, 2008, and 2017 do not overlap with the scores recorded in the 1980s, also suggesting the biotic integrity of the fish community has improved since monitoring began in the 1980s at CUVA (Figure 4.10-3).

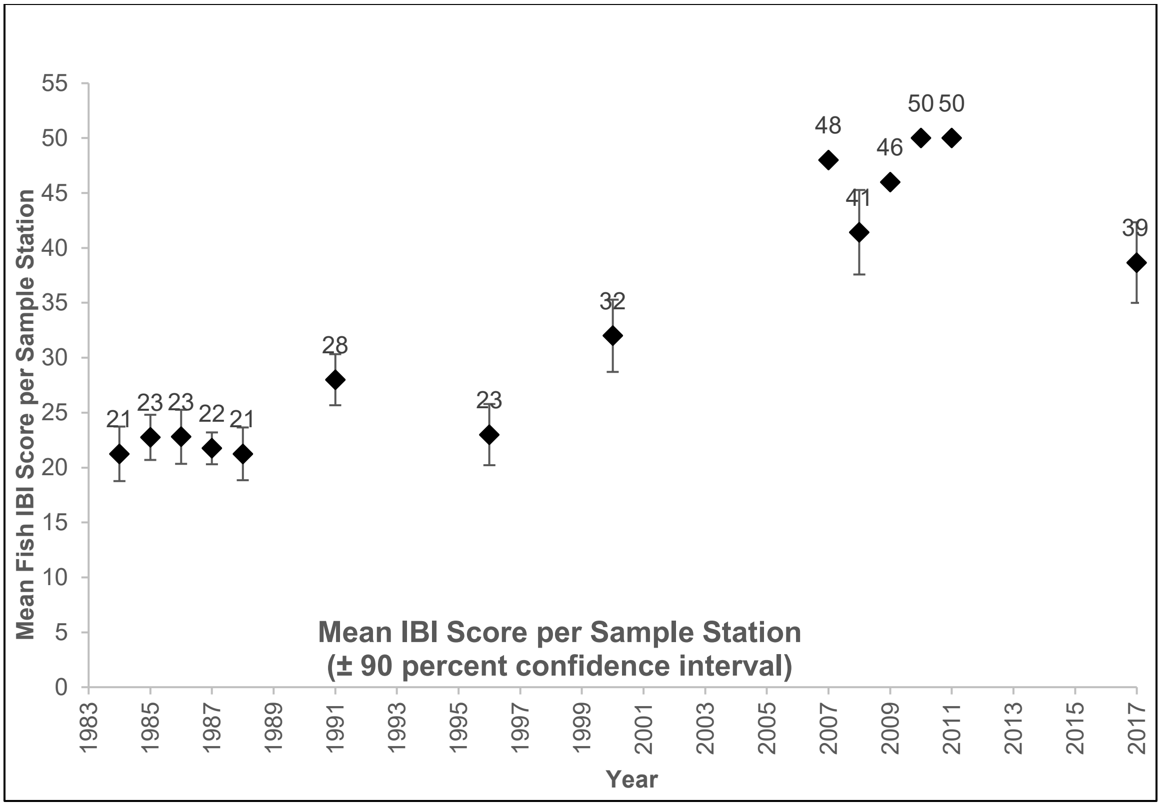

Figure 4.10-3. Mean fish IBI scores at Cuyahoga Valley National Park from 2001 to 2011 with 90 percent confidence intervals (data obtained from Ohio EPA).

Species of Concern

Over three decades of fish monitoring at CUVA and the 17 years in which fish were sampled within the Park, there has only been one year in which a fish species of concern was recorded. The longear sunfish (*Lepomis megalotis*) is listed as sensitive by the USFS and one individual was recorded at sample station 8 in 1988. Therefore, data was insufficient to determine the status of this indicator.

Overall Condition and Trend

The values for the metrics of native species richness, the fish IBI, and the number of species of concern present in 2017 indicate that the fish community at CUVA warrants moderate concern, with a community structure that is representative of a moderately disturbed landscape (Table 4.10-4).

Table 4.10-4. Condition assessment summary for fish at Cuyahoga Valley National Park.

Indicator	Condition Status/Trend	Rationale
Native Species Richness (S)		Mean native fish species richness per sample station has fluctuated between 9 and 36 species from 1984 to 2017 with mean richness equaling 26 species in 2017 (resource is in good condition). Analysis of the fish monitoring data indicates an improving trend in native species richness from 1984 to 2017.
Fish Index of Biotic Integrity		In 2017, the mean fish IBI score per sample station was 39 (warrants moderate concern). Analysis of the mean fish IBI scores indicates an improving trend in the biotic integrity of the fish community between 1984 and 2017.
Species of Conservation Concern		Current condition is undetermined. The only species of concern detected at CUVA was the longear sunfish. Only one individual of this USFS-listed sensitive species was recorded in 1988 during the 17 years of sampling conducted from 1984 to 2017 at CUVA.
Fish overall		**Condition warrants moderate concern with an improving trend. Confidence in the assessment is high.**

4.10.5. Sources of Expertise

Jeff Deshon, retired Biologist, Division of Surface Water, Ecological Assessment Section, Ohio EPA. Jeff provided the data for CUVA upon which this assessment is based and also designed the protocol used to monitor water Quality at the Ohio EPA (Emery et al. 2004). His research interests focus on water quality in lotic systems and assessment of water quality, habitat, and biota. Jeff Deshon's duties at the Ohio EPA have been taken over by Andrew Phillips, Environmental Specialist 2, Ohio EPA, Division of Surface Water, Ecological Assessment Section, Groveport, Ohio. Mr. Phillips supplied updated data which facilitated the assessment of the fish community at CUVA.

4.10.6. Data Gaps and Uncertainty

The 17 years of monitoring data available for this assessment collected over a 33 year period is a sound foundation and continued monitoring will enable the assessment of variability over time and space and assure the accuracy of the assessment (Dornelas et al. 2012).

One factor affecting the quality of the data is the probability that a fish that is present when electrofish sampling is occurring is detected. Electrofishing improves the probability of detecting a species, but because each stream reach is surveyed only once per year, there is always the chance that rare species will go undetected. This can be a problem when assessing native species richness and the number of species of conservation concern, and when calculating the index of biotic integrity, which is calculated based on the number of species within different guilds.

In addition, there were differences in sampling effort with more stream reaches being sampled in some years of monitoring. This confounding influence makes it difficult to identify whether differences in yearly results are from true changes in their values or are an artifact of the variation in sample effort. Sampling the same stream reaches and the same number of reaches in every year of monitoring would control for this bias. However, by comparing the mean value of the indicators for each stream reach sampled, we can, to some extent, control for unequal sample sizes and can examine differences in the values of the indicators by year.

4.10.7. Literature Cited

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4.11. Wetlands

4.11.1. Background and Importance

The U.S. Fish and Wildlife Service (USFWS) defines wetlands as: "transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water… Wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season." Wetlands generally include marshes, bogs, swamps, fens, prairie potholes, and other areas temporarily or permanently inundated by shallow water (Cowardin 1979).

Healthy wetlands provide many benefits (Mitsch and Gosselink 2000). It is well established that water quality is improved as wetland areas filter out nutrient loads and pollutants before they reach rivers and streams. Wetlands also moderate floodwaters and maintain minimum water flows. Another function of wetlands, which is especially important in terms of the NPS and CUVA mission, is that they provide habitat for a diversity of plants and wildlife, many of which are becoming increasingly scarce both locally and regionally due to continuing wetland losses. Wetlands can also serve as important stopover areas for migrating birds. In addition to their ecological significance, wetlands exhibit a variety of educational, recreational and aesthetic values.

Wetland habitats in Ohio are estimated to have declined in area by 90% between the 1780s and 1980s (Noss and Peters 1995). Most of these losses are attributed to draining and filling of wetland areas for agricultural use. Development and urban sprawl continually threaten the wetlands that remain in northeastern Ohio. These effects have been mitigated somewhat within the boundaries of CUVA, a National Park unit encompassing over 33,000 acres of relatively undeveloped land along 20 miles of the lower Cuyahoga River. Park-wide wetland inventories have documented more than 1500 wetland areas encompassing approximately 1900 acres at CUVA (Figure 4.11-1) (NPS 2013). Most of the wetlands are quite small, with only 245 (15.5%) greater than an acre in size and only 41 (2.6%) greater than 10 acres in size. Wetland types found in the park include marshes, wet meadows, scrub/shrub wetlands and forested wetlands.

The Cuyahoga River ecosystem is listed as a fundamental resource in CUVA's Foundation Document (NPS 2013), with wetlands playing an integral part in supporting the river's hydrology, water quality, biodiversity and other ecological and non-ecological attributes. CUVA wetlands are not only a valuable park resource—they also play an important role within the region. Given that almost half of Ohio's remaining wetlands may be isolated (NPS 2002) and recent Supreme Court rulings have ended or limited Army Corps of Engineer jurisdiction over such wetlands, the loss and degradation of remaining wetlands outside the park may increase.

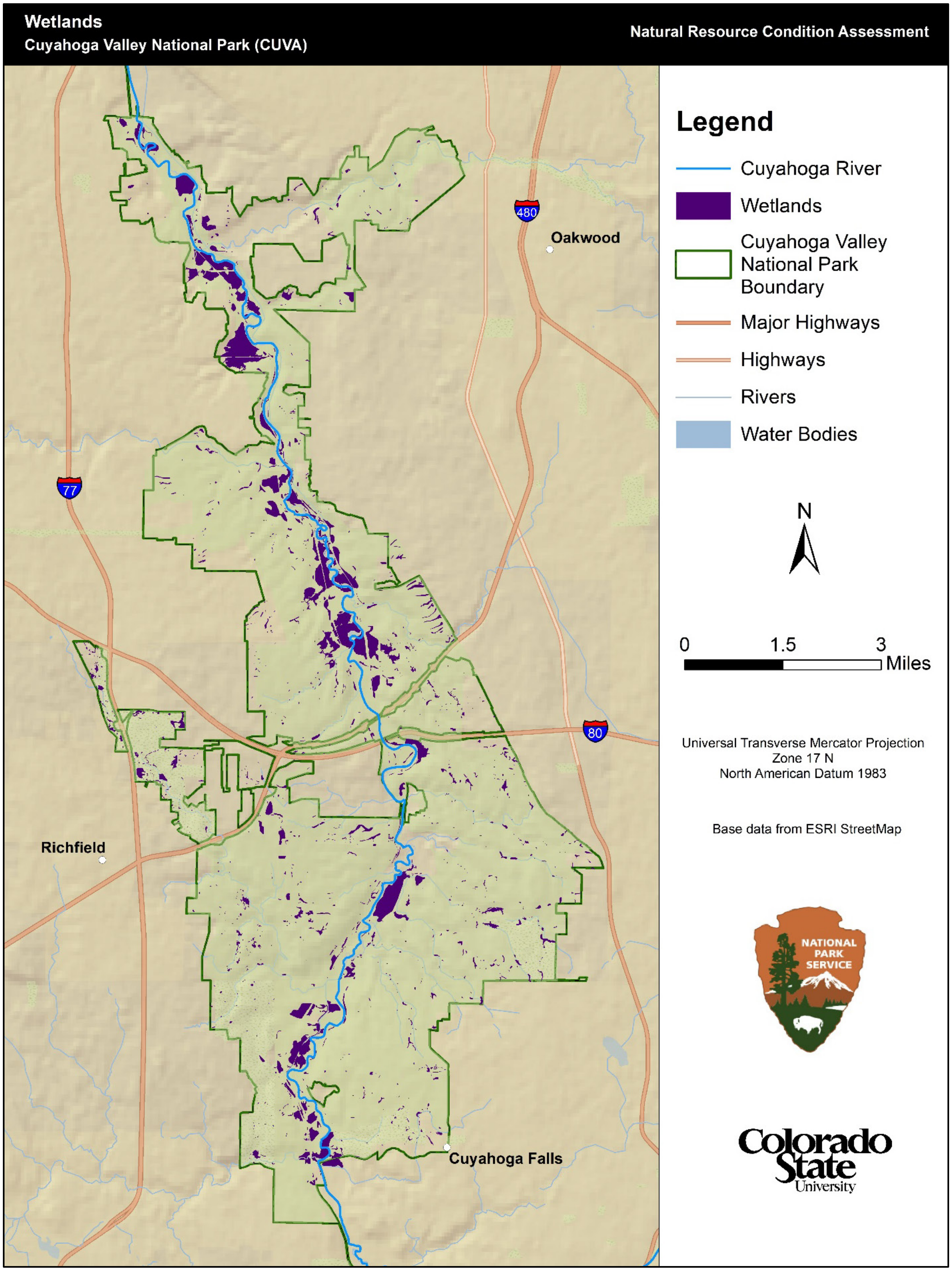


Figure 4.11-1. Distribution of wetlands at CUVA (wetland data from CUVA staff; base data from ESRI Streetmap).

NPS Management Policies (NPS 2001) and Executive Order 11990 "Protection of Wetlands" direct the NPS to minimize and mitigate the destruction, loss or degradation of wetlands; preserve, enhance and restore the natural and beneficial values of wetlands; and avoid direct and indirect support of new construction in wetlands unless there are no practicable alternatives and the proposed action includes all practicable measures to minimize harm to wetlands. NPS policies for implementing Executive Order 11990 in CUVA are found in Director's Order 77-1 "Wetland Protection" and the associated Procedural Manual.

The NPS has set a goal of "no net loss of wetlands" and requires that parks avoid adverse impacts to wetlands to the extent practicable for any new development or projects. The objectives outlined in the park's Resources Management Plan (NPS 1999) reflect these wetland protection mandates.

Wetland Types at CUVA

Overview of Wetlands at CUVA[5]

Nearly 78% of wetlands in the 813 square mile Cuyahoga River watershed are in good to excellent condition based on the Ohio Rapid Assessment Method (ORAM) for evaluating wetland integrity (Fennessy et al. 2007). The highest rates of degradation are found in wetlands within the lower sub-basin of the Cuyahoga River, which includes CUVA. However, rapid assessments conducted by various NPS staff, contractors and partners within CUVA between 1999 and 2014 indicate that 74% of the wetlands (n=595) and 89% of total wetland area within the park are in good to excellent condition (Bingham undated). The protected landscape provides an important buffer for over 43 small watersheds that flow into the lower Cuyahoga River sub-basin. CUVA wetlands are an integral part of this landscape, as they intercept, retain, filter, and recharge surface and groundwater as it flows from the upper watersheds outside of the park, through the park and into its stream system. These wetlands are complex ecological systems that provide nursery, resting, feeding, and breeding grounds for numerous species of amphibians, birds, fish, and other wildlife. For example, CUVA wetlands are known to support at least 12 species of amphibians. The park supports populations of at least 4 partially aquatic mammals, including *Mustela vison* (American mink), *Castor canadensis* (beaver), *Ondatra zibethicus* (muskrat), and *Lontra Canadensis* (Northern river otter). The Northern river otter was once extirpated from Ohio, but has been reproducing in the Beaver Marsh since 2013. The Beaver Marsh, Fawn Pond, and several other important wetlands in the park are known breeding grounds for over 45 different bird species (Marcum and Bingham 2017). More recently in 2016, CUVA documented a second occurrence of the state threatened, *Clemmys guttata* (spotted turtle) in the Beaver Marsh and nearby in an old canal wetland (M. Plona, unpublished data). These species use a variety of wetland features such as dense vegetation, large woody debris (logs), deep water, hummock topography, and standing dead trees.

The various wetland types in CUVA respond differently to environmental stress based on their water source and position in the landscape (i.e., hydrogeomorphic class or HGM). Ecological communities are impacted from air and water-born pollutants, physical damage, changes in groundwater levels or increased flooding, and other stressors (Brown and Vivas 2005). Nutrients and toxins carried in

[5] Adapted from Bingham et al. (2016).

storm and agricultural runoff negatively affect surface water and groundwater and any wetlands dependent on these water sources in affected watersheds (i.e., slope and riverine wetlands), which include the majority of CUVA wetlands (Table 4.11-1). Modifications to the inflow and outflow of surface and groundwater within a watershed will also result in measurable changes to wetland systems over time since wetland plant communities are sensitive to water level and water quality changes (Mitsch and Gosselink 2000). It is expected that land-use practices influence wetland integrity as a whole within CUVA boundaries more than any other environmental variable.

Land use varies considerably along the Cuyahoga River. Suburban development reduced forest and agricultural lands by nearly 25% in park subwatersheds between 1959 and 2002 (aerial photos 1959 and 2000/2002) (Skerl, unpublished). Fortunately, forested lands have generally increased within the park boundaries as agricultural fields revert to forest over time. Changes in land-use were minimal between 2001 and 2011 in park watersheds, according to an internally produced Land Development Index (Bingham 2016).

Table 4.11-1. Number and area of wetlands by hydrogeomorphic (HGM) class at CUVA (Bingham undated).

HGM Class	Number of Wetlands (% of total)	Acreage (% of total)
Slope	765 (48.1)	794.75 (40.6)
Depressional	402 (25.3)	259.6 (13.3)
Riverine[a]	407 (25.6)	832.1 (42.5)
Lucastrine Fringe	16 (1.0)	71.4 (3.7)
Total	**1590 (100)**	**1957.9 (100)**

[a] CUVA wetland data (Bingham undated) separates riverine headwaters and riverine mainstem wetlands. These categories have been combined for this assessment.

HGM Classification of Wetlands and Types Present at CUVA

The hydrogeomorphic (HGM) classification system for wetlands (Brinson 1993) was designed for evaluating wetland function. It has been used by numerous agencies to assess the physical and biological function of wetlands (Mitsch and Gosselink 2000). The HGM system is useful in comparing functional integrity of a wetland within its same functional class. HGM classification is based on three primary components: geomorphology (topographic location), water source (precipitation, surface flow, groundwater discharge), and hydrodynamics (direction and strength of water movement) (Mitsch and Gosselink 2000).

Four of the seven HGM types listed by the Natural Resources Conservation Service (NRCS 2008) are present at CUVA. Listed in order of decreasing acreage at CUVA, they are riverine, slope, depressional, and lacustrine fringe (hereafter called fringe). Riverine wetlands are located in flood plains and riparian corridors near streams and rivers. Slope wetlands are usually found where groundwater discharge meets the land surface. Depressional wetlands form in topographical depressions. Fringe wetlands at CUVA are wetlands at the edge of freshwater lakes or other larger bodies of water. For more information on each of the HGM types, see NRCS (2008). A generalized diagram of three of the wetland types found at CUVA and their position within the landscape are shown in Figure 4.11-2. For more specific information on wetland types by HGM class found at CUVA, see Bingham et al. 2016.

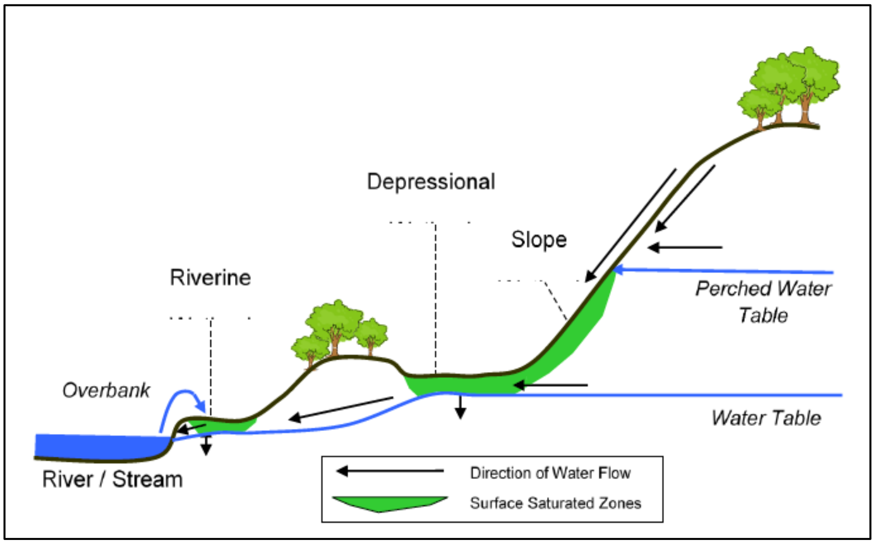


Figure 4.11-2. Cross-sectional view of dominant wetland hydrogeomorphic (HGM) classes found at CUVA (Bingham et al. 2016).

Wetland Classification by Dominant Vegetation and Types Present at CUVA

Several vegetation classification schemes for wetlands have been produced at both the national and local level. The most widely used in the U.S. is the U.S. Fish and Wildlife Service (Cowardin et al. 1979) system. The higher levels of this system are based on geomorphology and hydrology, and focus more on vegetation types further down, with broad vegetation types included at the class level (Mitsch and Gosselink 2000). Once at the class level, vegetation becomes the primary determinant of wetland class for wetlands with greater than 30% vegetative cover, while substrate is used for those with less than 30% cover (Mitsch and Gosselink 2000). For more information on this classification system, see Cowardin et al. (1979).

The system used at CUVA for classifying wetlands by vegetation type closely follows the USFWS classification system. These wetland types include emergent, forest, shrub, open water, and gravel bar (total area of wetlands by vegetation type has not been compiled for CUVA). Emergent wetlands, which can occur in several hydrogeomorphic settings, are characterized by "erect, rooted, herbaceous hydrophytes, excluding mosses and lichens." (Cowardin et al. 1979). A classic example of an emergent wetland would be the highly recognizable marsh filled with cattails. Forested wetlands are categorized by woody vegetation that is ≥ 6m in height. Shrub wetlands are similar to forested wetlands, except that woody vegetation is generally < 6m tall. Open water is generally characterized by deep water and lack of standing vegetation. Emergent wetlands may revert to open water in some years due to flooding or other disturbances. Gravel bar is not an official type within the Cowardin classification system.

Threats and Stressors

The most commonly cited threat to wetlands is adjacent land use. Due to the effects of adjacent land uses on wetlands, a number of states have established indicators to assess the impact of surrounding development and land use on wetlands, similar to the Landscape Development Index (LDI) used by the Ohio Environmental Protection Agency (OEPA) (Fennessy et al. 2007). Effects of adjacent land use on wetlands include destruction of ecological buffer zones, hydrologic and habitat isolation, runoff of pollutants and excessive nutrients from agricultural and other non-point source pollution sources, and other effects (Davey Resource Group 2006). Historical disturbance from mining, road and railroad disturbance, and altered hydrology are additional stressors.

Another major wetland stressor is the filling of wetlands for numerous purposes. Fill can consist of soil, rock, concrete, brick (Davey Resource Group 2006) or other natural or synthetic materials. The "no net loss of wetlands" policy established in the 1990s has largely stopped the practice of filling wetlands without proper mitigation and compensation, but the effects of past activities persist. Other stressors include trash dumping, hydrologic alteration by ditching and drainage tiling, all-terrain vehicle use, and others. Davey Resource Group (2006) conducted a wetland inventory for Cuyahoga County, noting the number of wetlands per impact category (Table 4.11-2). Although the area of interest is not identical to that of this document (within CUVA boundaries), these figures help show the extent of various threats and stressors within the region. Within the land use category, ongoing development and urban sprawl are the major threats to wetlands at CUVA and northeastern Ohio in general (NPS 2002).

Table 4.11-2. Summary of wetland impacts by impact type in Cuyahoga County, Ohio (adapted from Davey Resource Group 2006).

Impact	Percent of Wetlands (%)
None	52.0
Adjacent Land Use	9.7
Fill	6.5
Dumping	0.8
Logging	0.3
Drainage Tiling	0.5
Drainage Ditching	0.4
Other	2.7

CUVA's Pleasant Valley wetland site exemplifies a historically-disturbed wetland. The wetland is one of the largest riparian wetland complexes in the lower Cuyahoga River basin, with extensive historic impacts of mining as well as historical railroad disturbance and hydrologic alterations. The area does not drain freely, and the park is trying to reconnect several hundred acres of the wetlands to natural drainage patterns and the river. Some areas have been filled with contaminated coal fly ash/refuse. Soil from some portions of the site have been tested for contaminants. Wetlands at

Pleasant Valley have been monitored since 2007 as part of HTLN's long-term wetlands monitoring program (pers. comm. Sonia Bingham, September 2015).

Indicators and Measures

- Ohio Rapid Assessment Method (ORAM) 5.0 scores by wetland type
- Vegetation Index of Biotic Integrity (VIBI) scores

4.11.2. Data and Methods

A recently developed Wetland Monitoring Protocol for CUVA (Bingham et al. 2016) prescribes a combination of rapid assessment (Ohio Rapid Assessment Method or ORAM) and intensive assessment (Vegetation Index of Biotic Integrity or VIBI) protocols used by the OEPA to monitor wetlands statewide. Going forward, the ORAM 5.0 score will be used to rapidly assess 250 wetlands within CUVA, while the VIBI will be used to intensively assess 60 wetlands on an ongoing basis in the park (Bingham et al. 2016).

Ohio Rapid Assessment Method (ORAM)

The ORAM (Mack 2001) is primarily used to categorize wetlands with respect to Ohio's Wetland Anti-degradation Rule of May 1, 1998. The rule categorizes wetlands based on their function, sensitivity to disturbance, rarity, and irreplaceability, and places restrictions on development ranging from avoidance to minimization to mitigation. The categories are as follows:

- Category 1: Wetlands with minimal wetland function and/or integrity.
- Category 2: Wetlands with moderate wetland function and/or integrity.
- Category 3: Wetlands with superior wetland function and/or integrity.

These categories can be thought of as poor, good, and excellent, respectively. An implied fourth category is a modified Category 2, which reflects fair condition. A more detailed breakdown of wetland condition by ORAM score is shown in Table 4.11-3 (Mack 2001).

Table 4.11-3. ORAM v 5.0 scoring breakdown by condition category. Adapted from Mack (2001).

Category	ORAM v 5.0 Score
1	0–29.9
1 or 2 gray zone	30–34.9
Modified 2	35–44.9
2	45–59.9
2 or 3	60–64.9
3	65–100

The ORAM is calculated based on six categorical metrics—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—that characterize wetland condition. The protocol has been validated for use with other independent measures of ecological condition such as macroinvertebrate, bird, amphibian, and vegetation data (Mack 2001, Andreas et al. 2004, Micacchion 2004, Stein et al. 2009).

For the purposes of this analysis, sites sampled in 2016 were considered current data, while sites sampled between 1999 and 2014 were considered historical data for trend determination. Because these two sets of data were collected from different sites and cannot compared statistically over time, they are compared in a non-statistical fashion to give a general indication of the change in the ORAM metrics over time.

Vegetation Index of Biotic Integrity (VIBI)

The VIBI analyzes vegetation metrics as integrators and indicators of cumulative anthropogenic disturbance impacting wetlands. To customize the VIBI for different wetland types, three VIBI types are used: VIBI-Emergent, VIBI-Forest, and VIBI-Shrub. Among the three VIBIs, there are 19 metrics, although each VIBI type consists of only 10 metrics. Individual metrics can receive a score of 0, 3, 7, or 10. The VIBI is calculated by summing the 10 metric scores, yielding a potential score between 0 and 100 (Mack and Gara 2015). Generally speaking, scores above 57 and 70 fall within the Category 2 and 3 anti-degradation ranges discussed above, respectively. However, reference ranges are specific to each HGM type and plant community (see Table 4.11-4). For the purposes of this assessment, a single range of scores was used to assess the overall condition of wetlands via the VIBI score as shown in the next section. The anti-degradation categories used in Bingham et al. (2016) were converted to use the same nomenclature as ORAM categories, which helps in creating a standardized overall assessment using the three-tier NRCA system. Categories used in Bingham et al. (2016) are: Limited quality wetland habitat (LQWLH) corresponding with anti-degradation Category 1, restorable wetland habitat (RWLH) corresponding with the anti-degradation category Modified 2, wetland habitat (WLH) corresponds with the anti-degradation Category 2, and superior wetland habitat (SWLH) or Category 3.

Table 4.11-4. VIBI scoring ranges by condition category for specific vegetation types and HGM class. Adapted from Bingham et al. (2016).

		VIBI Score Range		
HGM Class	**Plant Community**	**Category 1**	**Modified Category 2**	**Category 2 or Category 3**
Depressional	Swamp Forest, Marsh, Shrub swamp	0–30	31–60	61–100
	Meadow	0–29	30–59	60–100
Slope	Wet Meadow, Fen, Forest Seep	0–29	30–59	60–100
Riverine	Wet Meadow	0–29	30–59	60–100
	Other Communities (headwater)	0–27	28–56	57–100
	Other Communities (mainstem)	0–29	30–56	57–100
Lacustrine Fringe	Marsh, Shrub swamp	0–26	27–52	53–100
	Wet Meadow	0–29	30–59	60–100

The recently developed CUVA Wetland Monitoring Protocol assessed 35 “sentinel sites”, which included potential reference wetlands and wetlands of management concern. The previously mentioned survey sites were created to be sampled on an ongoing basis to determine trends that may “lead to scientific insights that link wetland condition to watershed stress, which could lead to more specific research or lead to agreement on projects such as stream and wetland restoration projects” (Bingham et al. 2016). For the purposes of this analysis, survey sites sampled in 2015 will be considered current data, while sentinel sites sampled between 2008 and 2014 will represent conditions in the recent past, but will not be used for trend comparison due to major differences in the sampling design.

4.11.3. Reference Conditions

The reference condition rating framework for the ORAM and VIBI indicators for wetlands at CUVA follow published scoring ranges for ORAM and VIBI scores for anti-degradation categories (Category 1, 2, and 3 wetlands) (Table 4.11-3 and 4.11-4). The condition rating system for ORAM and VIBI is presented in Table 4.11-5.

Table 4.11-5. Reference condition rating framework for wetlands at CUVA. Adapted from Mack 2001 and Mack and Gara 2015.

Indicator	Good Condition (mean score Category 2 or higher)	Warrants Moderate Concern (mean score Category 1 or 2 gray zone to modified 2)	Warrants Significant Concern (mean score Category 1)
ORAM v 5.0 Score	≥ 45	30–44.9	≤ 29.9
VIBI Score	≥ 57	31–56	≤ 30

The OEPA considers Category 2 and 3 wetlands as “good” quality wetlands, although the lower end of Category 2 can be considered “degraded but restorable” (Mack 2001). For the purposes of this analysis, Category 2 and 3 wetlands (ORAM ≥ 45 or VIBI ≥ 57) will be placed in the “good condition” category (Table 4.11-5). Wetlands that are within the Category 1 or 2 gray zone to modified Category 2 (ORAM 30–44.9 or VIBI 31–56) will be assigned a “moderate condition”, while wetlands in Category 1 (ORAM ≤ 29.9 or VIBI ≤ 30) will be assigned a “poor condition” (Table 4.11-5).

4.11.4. Condition and Trend

<u>Ohio Rapid Assessment Method (ORAM)</u>

More than 63% of CUVA wetlands and more than 93% of wetland acreage sampled using the ORAM protocol in 2016 were Category 2 or greater, with a mean score of 47.9 for all wetlands (Table 4.11-6). Descriptive statistics for ORAM scores for CUVA wetlands by HGM and plant community type are summarized in Table 4.11-7.

Table 4.11-6. Number of wetlands and wetland area by condition category for ORAM sampling in 2016 (Bingham undated).

Condition Category	Number of Wetland Sites (% of total)	Total Acreage (% of total)
Category 3[a]	12 (4.8)	185.0 (40.3)
Category 2 or 3[a]	17 (6.8)	61.0 (13.3)
Category 2[a]	130 (52.0)	181.2 (39.5)
Modified Category 2	62 (24.8)	22.2 (4.9)
Category 1 or 2	15 (6.0)	7.2 (1.6)
Category 1	12 (4.8)	2.0 (0.4)
All	250 (100)	458.6 (100)

[a] Categories assigned "good condition" (also shaded).

Table 4.11-7. ORAM results for CUVA wetlands sampled in 2016 by hydrogeomorphic type, plant community type and watershed (Bingham undated). ND = No Data.

Component	Type	Number of Sites (% of total)	Mean (SD) ORAM Score	Total Acreage (% of total)
All	–	250	47.9 (10.5)	458.6 (100)
Hydrogeomorphic	Slope	129 (51.6)	47.9 (9.4)	90.3 (19.7)
	Depression	64 (25.6)	44.1 (12.9)	131.8 (28.7)
	Riverine	56 (22.4)	52.3 (8.0)	236.3 (51.5)
	Fringe	1 (0.4)	31.0 (-)	0.2 (<0.1)
Plant Community	Emergent	187 (74.8)	46.8 (10.8)	252.3 (55.0)
	Forest	35 (14.0)	51.2 (8.3)	136.1 (29.7)
	Shrub	23 (9.2)	50.5 (10.6)	68.2 (14.9)
	Gravel Bar	3 (1.2)	50.7 (2.5)	0.5 (0.1)
	Open Water	2 (0.8)	54.8 (4.6)	1.5 (0.3)
HUC 12 Watershed (listed upstream to downstream)	City of Akron-Little Cuyahoga River	ND	ND	ND
	Boston Run-Cuyahoga River	131 (52.4)	46.9 (11.4)	228.9 (49.0)
	Mud Brook	ND	ND	ND
	Yellow Creek	5 (2.0)	49.0 (7.3)	19.4 (4.2)
	Furnace Run	33 (13.2)	47.3 (8.2)	18.9 (4.0)
	Brandywine Creek	10 (4.0)	49.0 (7.5)	10.7 (2.3)
	Willow Lake-Cuyahoga River	53 (21.2)	49.7 (9.36)	174.1 (37.27)

Table 4.11-7 (continued). ORAM results for CUVA wetlands sampled in 2016 by hydrogeomorphic type, plant community type and watershed (Bingham undated). ND = No Data.

Component	Type	Number of Sites (% of total)	Mean (SD) ORAM Score	Total Acreage (% of total)
HUC 12 Watershed (listed upstream to downstream) (cont.)	Headwaters Chippewa Creek	6 (2.4)	58.6 (12.6)	3.9 (0.8)
	Town of Twinsburg – Tinker's Creek	6 (2.4)	50.0 (4.3)	3.6 (0.8)
	Village of Independence – Cuyahoga River	6 (2.4)	40.3 (13.0)	7.7 (1.6)
	Town of Cuyahoga Heights – Cuyahoga River	ND	ND	ND

For hydrogeomorphic types, slope and riverine wetlands meet the criteria for a rating of good condition, while fringe and depressional wetlands are in the moderately impaired category. The fringe type consists of a single wetland measuring only 0.2 acres in area. The depressional type occurs commonly, with 64 units totaling nearly 132 acres (28.7% of total wetland area). However, the mean ORAM score for depressional wetlands was only 0.9 points away from a good rating. For plant community, all types meet the criteria for a good condition rating. ORAM scores divided by watershed show that all watersheds analyzed are in good condition (Table 4.11-9).

Because data collected by park staff from 1999 to 2014 were collected from different sites than the survey sites sampled in 2016, they do not constitute a statistically valid comparison for the 2016 data. The data from 1999 to 2014 fall within the good condition category at 48.9±13.8 (n = 595), similar to that of the 2016 data. The published mean (standard deviation) ORAM score in the entire Cuyahoga River watershed was 55.6 (14.5) (Fennessy 2007).

<u>Vegetation Index of Biotic Integrity</u>

More than 46% of CUVA wetlands sampled using the VIBI protocol in 2015 were Category 2 or greater (Table 4.11-8). Acreages were not included in VIBI sampling data. Descriptive statistics for VIBI scores for CUVA wetlands are summarized in Table 4.11-9.

Table 4.11-8. Number of wetlands by condition category for VIBI sampling in 2015 (Bingham undated).

Condition Category	Number of Wetland Sites (% of total)
Category 3[a]	3 (5.0)
Category 2[a]	25 (41.7)
Modified Category 2	24 (40.0)
Category 1	7 (11.7)
None Assigned	1 (1.7)
All	60 (100)

[a] Categories assigned "good condition" (also shaded).

Table 4.11-9. Mean (standard deviation) VIBI scores for CUVA wetlands sampled in 2015 by hydrogeomorphic type, plant community type and watershed (Bingham undated). ND = No Data.

VIBI Component	Type	N (% of total)	2015 Mean (SD) VIBI Score
All	–	59[a] (100)	52.4 (17.3)
Hydrogeomorphic	Slope	30 (50.1)	59.4 (11.1)
	Riverine	21 (35.6)	47.0 (21.2)
	Depression	8 (13.6)	40.5 (15.0)
Plant Community	Emergent	33 (55.9)	51.9 (17.4)
	Forest	25 (42.4)	53.3 (17.8)
	Shrub	1 (1.7)	48 (-)
HUC 12 Watershed (listed upstream to downstream)[b]	City of Akron-Little Cuyahoga River	ND	ND
	Boston Run-Cuyahoga River	25 (43.9)	51.8 (17.6)
	Mud Brook	ND	ND
	Yellow Creek	ND	ND
	Furnace Run	ND	ND
	Brandywine Creek	6 (10.5)	57.3 (11.9)
	Willow Lake-Cuyahoga River	10 (17.5)	53.0 (22.1)
	Headwaters Chippewa Creek	8 (14.0)	55.9 (16.5)
	Town of Twinsburg – Tinker's Creek	4 (7.0)	49.8 (14.2)
	Village of Independence – Cuyahoga River	4 (7.0)	49.5 (26.5)
	Town of Cuyahoga Heights – Cuyahoga River	ND	ND

[a] One wetland sampled did not have a VIBI score and was not included in calculations.

[b] Two wetlands sampled had conflicting identification and location data and were removed from the watershed-level analysis (n = 57).

The overall mean for VIBI in 2015 was 52.4±17.3, falling in the moderately impaired category. Slope wetlands had the highest VIBI mean by HGM class, at 59.4±11.1, meeting the criteria for a good condition rating. All vegetation types were in the moderately impaired category, with forest wetlands being the highest at 53.3±17.8. Of the watersheds that contained VIBI data, wetlands within Headwaters Chippewa Creek and Brandywine Creek were in the best condition at 55.9±16.5 and 57.3±11.9, respectively. In general, VIBI wetland condition tended to be more impaired further downstream.

Data collected by park staff from 2008 to 2014 is summarized in Table 4.11-10. Note that these data were collected from different sites than the survey sites sampled in 2015 and were chosen non-randomly to represent high-functioning reference sites for each wetland type as well as wetlands of management concern (WOMC) chosen by park staff as wetlands and wetland complexes that are particularly important to the ecology of the area. As such, these data summaries are only used as a general indication of the condition of wetlands in the recent past at CUVA and will not be used to determine a trend for the VIBI indicator. Overall, the data from 2008 to 2014 fall within the moderately impaired condition category at 48.7±22.8 (n = 35), similar to that of the 2015 data. Reference sites scored high (60.6±29.5) while WOMC scored relatively low and were well within the moderately impaired category (38.8±21.8).

Table 4.11-10. Mean (standard deviation) VIBI scores for CUVA sentinel site wetlands sampled from 2008 to 2015 by hydrogeomorphic type and plant community (Bingham undated).

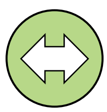
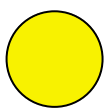
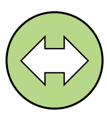
VIBI Component	Type	Sample Size (% of total by type)	2008 to 2014 Mean VIBI Score (SD)
Reference	–	8	60.6 (29.5)
Hydrogeomorphic	Slope	2 (25.0)	85.5 (2.1)
	Riverine	4 (50.0)	51.8 (29.3)
	Depression	2 (25.0)	53.5 (43.1)
Plant Community	Emergent	4 (50.0)	79.8 (14.7)
	Forest	2 (25.0)	29.5 (9.2)
	Shrub	2 (25.0)	53.5 (43.1)
Wetlands of Management Concern (WOMC)	–	29	38.8 (21.8)
Hydrogeomorphic	Slope	6 (20.1)	42.8 (16.1)
	Riverine	19 (65.5)	40.5 (24.0)
	Depression	4 (13.8)	25.0 (16.0)
Plant Community	Emergent	21 (72.4)	36.8 (24.4)
	Forest	8 (27.6)	44.3 (12.8)

Although VIBI scores have been calculated in the past for the area (Mack 2004, for the Erie-Ontario Drift Ecoregion), no other study has been completed exclusively within the boundaries of CUVA, and thus there is no direct comparison to determine trend for wetlands at CUVA. Continued efforts by NPS staff will allow for a more robust trend analysis for this metric in the future. Mack (2004) listed the mean (standard deviation) VIBI score in the ecoregion (Erie-Ontario Drift) as 47.0±27.6, while data from the park showed that wetlands within CUVA were generally in the same condition in 2015 (48.2±21.2).

Overall Condition

The data presented above suggest that in general, wetlands at CUVA are in good condition, with an unchanging trend (Table 4.11-11). Although the condition of wetlands within CUVA has substantial room for improvement, they are in good condition when compared with wetlands in Ohio and the upper Midwest as a whole. The confidence associated with these ratings is medium due to the limited availability of data over time.

Table 4.11-11. Condition and trend summary for wetlands at Cuyahoga Valley National Park.

Indicator	Condition Status/Trend	Rationale
ORAM v 5.0 Score		The mean ORAM score for CUVA wetlands is 47.9. More than 90% of the acreage of CUVA wetlands are in good or excellent condition (Category 2 or 3) according to the ORAM v 5.0 Categorization Scheme. Data collected within CUVA from 1999 to 2014 indicates an unchanging trend when compared with 2016 data.
VIBI Score		The mean VIBI score for CUVA wetlands in 2015 was 49.4, placing this indicator in the moderate condition category, with no trend due to a lack of comparable historical datasets.
Wetlands overall		**Resource is in good condition, with an unchanging trend. Confidence in the assessment is medium.**

4.11.5. Uncertainty and Data Gaps

Inconsistencies in historical data allow for park-wide trend estimation for ORAM but not for VIBI trend determination. This will be resolved in the near future with ongoing monitoring by HTLN staff. This ongoing data collection will allow for a more robust trend analysis (by hydrogeomorphic type, plant community type, and watershed) for these indicators.

4.11.6. Sources of Expertise

- Sonia Bingham, Wetland Biologist, Cuyahoga Valley National Park
- Meg Plona, Biologist, Cuyahoga Valley National Park

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Chapter 5. Discussion

This section summarizes condition and trend results by focal resource, highlights management implications and interrelationships among resources, reinforces relationships between resource condition and landscape context elements, and consolidates data gaps.

5.1. Condition Summary and Management Implications

A total of 11 focal resources were examined: four addressing landscape context – system and human dimensions, two addressing chemical and physical attributes, and five addressing biological or integrated attributes. Status and trend assigned to each focal resource and a synopsis of supporting rationale are presented in Table 5.1-1.

5.1.1. Landscape Context –System and Human Dimensions

Landscape context – system and human dimensions included land cover and land use, night sky, soundscape, and climate change (Table 5.1-1). Climate change and land cover/land use were not assigned a condition or trend—they provide important context to the Park and many natural resources, and can be stressors. Some of the land cover and land use-related stressors at CUVA and in the larger region are related to the development of rural agricultural land and increases in population/housing over time. The trend in land development, coupled with the lack of significantly-sized and linked protected areas, presents significant challenges to the conservation of natural resources of CUVA to also include natural night skies, natural sounds and scenery. Climate change is happening and is affecting resources, but is not considered *good* or *bad* per se. The information synthesized in that section is useful in examining potential trends in the vulnerability of sensitive resources and broad habitat types such as forests. Night skies and soundscapes, significantly altered by disturbance due to traffic, development and urbanization, both warrant significant concern and appear to be in further decline.

There are opportunities to mitigate the effects of local landscape context stressors through planning, management and mitigation. Stressors driven by more distant factors such as light pollution generated by urban centers and increase in regional transportation volumes affecting sights and sounds are more difficult to mitigate. The results for these landscape-scale indicators support resource planning and management within the Park, and provides a foundation for collaborative conservation with other landowners in the surrounding area.

5.1.2. Chemical and Physical Environment

The supporting chemical and physical environment at the park include its air quality and water quality (Table 5.1-1). The condition of these resources can affect human dimensions of the park such as visibility and scenery as well as biological components such as vegetation health and stream biota. Air quality warrants significant concern, while water quality warrants moderate concern.

Table 5.1-1. Summary of focal resource condition and trend for Cuyahoga Valley National Park.

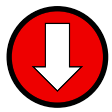
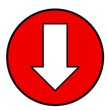
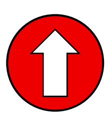
Ecosystem Attribute	Resource	Condition and Trend	Rationale for Overall Condition/Trend Rating
Landscape Context – System and Human Dimensions	Land Cover and Land Use	condition and trend not assigned	CUVA is within an exurban/suburban matrix landscape with a high proportion of developed land. Most of the stressors to the landscape surrounding CUVA are related to the conversion of forest to housing developments, most of which is classed as exurban. This trend in land development, coupled with the lack of well-connected protected areas, should be of concern to the conservation of natural resources of the park. Overall, the status and degree of these threats and stressors on the park are low in comparison to other federal and state parks in the region.
	Natural Night Sky		Median ALR for Cuyahoga Valley National Park is 17.75, which is considered a poor condition. Trend is deteriorating based on recent and anticipated increases in development and urbanization. No lighting ordinances or formalized light pollution mitigation efforts are currently in place in these urban centers.
	Soundscape		Results indicate that the condition of the soundscape at CUVA warrants significant concern, with a deteriorating trend due to projections for increased ground and air traffic over time. Nationwide modeling of anthropogenic sound level impacts indicates that modern noise intrusions are substantially increasing the existing ambient sound level above the natural ambient sound level of the park As long as noise from the adjacent roads and development remains pervasive in the park, the condition of the soundscape will likely continue to deteriorate.
	Climate Change	condition and trend not assigned	CUVA's climate is already becoming wetter, hotter, and is potentially more prone to more frequent and extreme weather events. Trends are projected to continue or accelerate by the end of the century. Research and monitoring related to climate change, the anticipated vulnerability of specific resources vis-a-vis climate change, and its associated effects on resources and interaction with other ecological processes can be informed by this broad overview of the magnitude of climate change. It also supports ongoing, anticipatory and adaptive management. More specific climate change adaptation tools and techniques appear to be needed at the park scale.
Chemical and Physical Environment	Air Quality		Based on the evaluation of air quality indicators, air quality condition warrants significant concern, with an improving trend. Confidence in the assessment is medium. Impacts to air quality appear to be largely from distant sources that are affecting regional air quality.

Table 5.1-1 (continued). Summary of focal resource condition and trend for Cuyahoga Valley National Park.

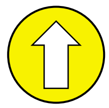
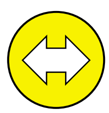
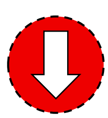
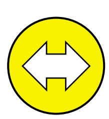
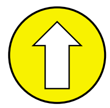
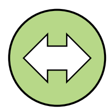
Ecosystem Attribute	Resource	Condition and Trend	Rationale for Overall Condition/Trend Rating
Chemical and Physical Environment (cont.)	Water Quality		The current condition of water quality in CUVA warrants moderate concern due to the impairments of E. coli for recreational use and mixed results for aquatic life use. Assessing the current condition and trend of water quality is challenging due to the age of most monitoring data and numerous agencies collecting data around and within CUVA using different study designs and collection standards. Recent efforts by CUVA and OEPA to collect water quality data more frequently will improve the quality of future assessments, especially for recreational contact and E. coli. Although the status of water quality at CUVA and in the region is still impaired, efforts by the park and other public and private entities have greatly improved the well-being of the Cuyahoga River and its tributaries since the 1960s.
Biological – Plants	Forest Communities		Results consolidated across multiple indicators suggest the current condition of both upland and bottomland forests at CUVA warrants moderate concern, with an unchanging trend and medium confidence. The forests are largely successional forests developing under a variety of disturbances. Overall trends are difficult to assess but there are factors that indicate current forest conditions will change in the near future. For instance, as white-tail deer management is initiated, impacts related to deer over browsing should subsided resulting in an improved condition. Alternatively, modeled data predicts CUVA forest will be impacted by a variety of disease and pest issues as well as changes in climate with these impacts having the potential to drastically affect future forest composition and structure. The combined and synergistic effects of these factors along with other anthropogenic disturbances (e.g., fire suppression, urban development, hydrologic changes) will determine the future trajectory of CUVA forest condition.
Biological – Animals	Bats		Data representing native species richness and the number of species of concern indicate that the condition of the bat community at CUVA warrants significant concern, with statistically significant declines in both richness and the species of conservation concern occurring between 2002 and 2015. The overall condition of the bat community warrants significant concern with a declining trend; confidence in the assessment is low due to inconsistent sampling methods.
	Riparian Birds		The values for the metrics used indicate that the condition of the bird communities at CUVA warrants moderate concern, with a number of obligate marshland birds and a community structure that is representative of a moderately disturbed landscape. Results for the survey period suggest an unchanging trend in bird community diversity and structure at CUVA. Confidence in the assessment is medium.

Table 5.1-1 (continued). Summary of focal resource condition and trend for Cuyahoga Valley National Park.

Ecosystem Attribute	Resource	Condition and Trend	Rationale for Overall Condition/Trend Rating
Biological – Animals (cont.)	Fish		The values for the metrics of native species richness, the fish IBI, and the number of species of concern present in 2017 indicate that the fish community at CUVA warrants moderate condition, with a community structure that is representative of a moderately disturbed landscape. The condition of native species richness and fish IBI has been improving since 1984, when the first sampling effort was conducted, giving this resource an improving trend. Confidence in the assessment is high due to the availability of long-term data.
Integrated Biological/ Environmental	Wetlands		In general, wetlands at CUVA are in good condition, with an unchanging trend. The available data did not allow for a trend determination. Although the condition of wetlands within CUVA has substantial room for improvement, they are in good condition when compared with wetlands in Ohio and the upper-Midwest as a whole. The confidence associated with these ratings is medium due to the limited availability of data over time.

Conditions were estimated to be improving for both resources. Air quality and water quality in CUVA are significantly impacted by historical and current land uses outside the Park boundary. Water quality in most tributaries to the Cuyahoga River that were evaluated have a majority (or the entirety) of the watershed outside the park boundary, limiting management options for the park and requiring the establishment of working relationships with other governmental and private entities. Water quality is further discussed in section 5.1.5 below.

5.1.3. Biological Component – Plants

The sole floral biological component examined was upland and bottomland forests (Table 5.1-1). Forest resources at CUVA have been influenced by historical land uses that have changed the species composition and age structure of the forest. The park contains some of the largest remaining forest tracts in northeast Ohio, helping to support biodiversity as well as provide corridors for migratory wildlife species. Although large tracts of forests can be found within the park, the majority of the forested areas are fragmented, and few areas within CUVA exhibit late-successional or old-growth characteristics. Condition metrics included invasive nonnative plants, forest pests and diseases, and native plant species composition. Forest communities at CUVA have a long history of being impacted by a variety of stressors and threats including noxious and invasive weeds, diseases and insect pests, compounding effects of climate change, air pollution, acid rain/atmospheric chemistry, past land uses, and impacts associated with overabundant white-tail deer populations. These stressors and threats have collectively shaped and continue to impact forest community condition and ecological succession. The condition of both upland and bottomland forests warrant moderate concern. The management of white-tail deer is anticipated to greatly benefit forest structure and composition in the future.

5.1.4. Biological Component – Animals

The faunal biological components examined included bats, birds, and fish (Table 5.1-1). Birds (unchanging trend) and fish (improving trend) warrant moderate concern, while bat populations warrant significant concern and are in decline. The fragmentation of habitat and conversion of native vegetation to urban landscapes outside the park can negatively impact populations of some bats and birds at CUVA. The park contains some relatively unfragmented patches of habitat that provide refugia within an altered and urbanized regional landscape. Increased protection and restoration of caves, riparian forests and wetlands increase community abundance and diversity for bats and birds over time.

Historical water quality degradation and restricted migration due to dams have and continue to be a challenge to fish conservation at the park. The fish community has responded as water quality has improved and numerous projects have been implemented, including native habitat restoration, reconnection of the floodplain to the river corridor, dam removal, barrier and impoundment bypass and removal, improved and comprehensive sewage treatment, and flow modifications within CUVA and the larger watershed (Tetra Tech 2017).

5.1.5. Integrated Biological/Environmental

Wetlands provide key habitat for numerous species and are sensitive to changes in water quality and hydrology. In general, wetlands at CUVA are in good condition, with an unchanging trend. Although the condition of wetlands within CUVA has substantial room for improvement, they are in good condition when compared with wetlands in Ohio and the upper Midwest as a whole.

5.1.6. Cuyahoga River Ecosystem Resources

Listed as a Fundamental Resource Value in the CUVA Foundation Document (NPS 2013), the Cuyahoga River and its ecosystem is the single most important natural feature in the park. When we examined focal resources related to the river ecosystem, four of five resources (water quality, bottomland forests, riparian birds and fish) warrant moderate concern. Water quality and fish resources were improving while birds and forests had overall unchanging trends. Wetlands were determined to be in good condition with an unchanging trend, although park staff indicate that the condition of wetlands in CUVA is improving. These results for the river system indicate that recent improvements in water quality within the watershed and recovery from the industrial era are resulting in a healthier river. However, the riparian and wetland habitats may need more time and effort to support the species that depend upon them.

In addition to the condition and trends discussed previously, the CUVA Foundation Document highlights the following topics, ongoing issues and successes related to the Cuyahoga River Ecosystem (NPS 2013):

<u>Condition</u>

- Due to its location within the park, the Cuyahoga River is designated a State Resource Water in Ohio under the Clean Water Act. A State Resource Water is defined by Paragraph (a) (25) of rule 3745-1-05 of the Ohio Administrative Code as a designation of a high quality water body (OEPA 2017). NPS lands provide some of the least impacted stream habitat remaining in the Midwest and streams at CUVA offer quality habitat for native fishes (Williams 2009).

- The Cuyahoga River ecosystem is altered and confined by park infrastructure (roads, rail, trail, structures). Historically, the river would have migrated laterally within its floodplain wherever it was not naturally confined by bedrock or canyon walls.

- Several tributaries to the Cuyahoga River are designated as cold water habitat. Waterbodies listed as Coldwater Habitat (CWH) in the State of Ohio "support assemblages of coldwater organisms and/or are stocked with salmonids" (OEPA 1999). Within CUVA, Boston Run, Salt Run, Langes Run, Robinson Run, Woodward Creek, Slipper Run and portions of Sagamore Creek are all designated as CWH (OEPA 2017).

<u>Local and Regional Trends or Anticipated Events</u>

- The Cuyahoga River is approaching possible delisting from the Great Lakes Areas of Concern. Partial delisting requests were released in 2009 and 2015 (CRRAPCC 2009, Cuyahoga River Restoration 2015).

- Organizations and agencies in the region are increasing efforts in regional watershed planning and stewardship. Several tributaries to the Cuyahoga River have their own watershed stewardship groups and planning documents, helping ensure water flowing into the Cuyahoga River is as clean as possible.

- Temperature and precipitation have shown a statistically significant increase during the 20th century. An increase in intense storm events and a shift in the percent of precipitation falling as snow versus rain could alter the hydrology and ecology of the Cuyahoga River and its tributaries.

- Planned removal/re-engineering of the Breckville dam will enhance water quality, improve the natural flow regime, and allow passage by native fish from Lake Erie and the lower river reach. Despite possible risks associated with nonnative invasive aquatic species, this initiative is anticipated to have net benefits to the ecosystem.

Major challenges that remain to the continued improvement of the Cuyahoga River ecosystem include high levels of *E. coli* in the river after storms due to runoff and sewer overflows, introduction of aquatic invasive species including fish and mollusks, remaining dams and other impoundments, introduction and spread of invasive exotic plants and forest pests and diseases, continued forest alteration by white-tailed deer overabundance, and a high vulnerability to climate change for many of the bottomland forest species present at CUVA.

5.2. Data Gaps and Uncertainties

The identification of data gaps during the course of the assessment is an important NRCA outcome (Table 5.2-1). Resource-specific details are presented in each resource section. In some cases, significant data gaps contributed to the resource not being evaluated or low confidence in the condition or trend being assigned to a resource. Primary data gaps and uncertainties encountered were lack of recent survey data; uncertainties regarding reference conditions; availability of consistent, long-term data; and more robust sampling designs.

Table 5.2-1. Data gaps identified for focal resources examined at Cuyahoga Valley National Park.

Ecosystem Attribute	Resource	Data Gaps and Uncertainties
Landscape Context – System and Human Dimensions	Land Cover and Land Use	Condition/status of other protected lands in the region.
	Night Sky	No on-site night sky monitoring studies have been conducted by the NPS in Cuyahoga Valley National Park. Condition and trend are based on modelled data.
	Soundscape	No acoustical monitoring studies have been conducted inside CUVA. Condition and trend are based on modelled data.
	Climate Change	Climate change projections are complex with inherently high uncertainty. More specific guidance for park adaptation is needed with regard to the Cuyahoga River system, forests, wetlands, and other resources.
Chemical and Physical Environment	Air Quality	Local air monitoring stations vs. interpolated regional data would improve accuracy.
	Water Quality	Additional sampling of cold water habitat streams should be implemented to determine their status over time. Collaboration with other public and private entities to standardize water quality sampling efforts will allow more robust analyses to be conducted in the future.
Biological – Plants	Forest Communities	Additional modeling along with continued forest monitoring should be continued to help understand the cumulative impacts of anthropogenic stressors, white-tail deer overabundance, forest health, and climate change impacts. A comprehensive inventory of late successional and old-growth forest areas is recommended along with rare plant inventories and monitoring. A landscape level, long-term vegetation monitoring program should be implemented to further understand these impacts across the park.
Biological – Animals	Bats	Improved consistency in sampling design and data collection may increase the power of the data.
	Birds	An increase in sampling frequency and in the number of sampling sites will increase the statistical strength of the data and may increase detection of species that may only be present seasonally.
	Fish	Consistency in sampling effort would further increase the power of the data in determining future condition and trends.
Integrated Biological/ Environmental	Wetlands	A lack of comparable historical data would only allow for a park-wide trend for ORAM and no trend for VIBI. This will be resolved in the near future with continuous monitoring already planned by park staff. This ongoing data collection will allow for a more robust trend analysis (by hydrogeomorphic type, plant community type, and watershed) for these indicators.

5.3. Conclusions

CUVA is a young park with a long history of human settlement and environmental impacts associated with agriculture, industrialization, environmental pollution and ecological disturbance. The challenges associated with managing resources within a partnership park that is heavily influenced by its urban fringes are manifold. Impacts associated with development outside the park will continue to stress some resources, and regionally, the direct and indirect effects of climate change are likely but specific outcomes are uncertain. Nonetheless, within the past several decades, significant strides have been made in restoring the quality of natural resources, most notably the biological, physical and chemical components comprising the Cuyahoga River Ecosystem within the park. Regional and park-specific mitigation and adaptation strategies are needed to maintain or improve the condition of some resources over time. Success will require acknowledging a "dynamic change context" that manages widespread and volatile problems while confronting uncertainties, managing natural and cultural resources simultaneously and interdependently, developing broad disciplinary and interdisciplinary knowledge, and establishing connectivity across broad landscapes beyond park borders (National Park Service Advisory Board Science Committee 2012).

5.4. Literature Cited

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