



Ozone and Foliar Injury Summary, 2019

Overview

Ozone is a gas that occurs naturally in the lower levels of the earth's atmosphere. However, human activities can become an unnatural source of pollutants which react to produce additional ozone that results in injury to humans and plants. The Cumberland Piedmont Network (CUPN) has been monitoring ozone and its injury to plants since 2008 to fulfill the National Park Service (NPS) mandate to protect its resources and preserve the enjoyment of these resources. Ozone concentration sampling was discontinued in 2017 but foliar injury sampling continues uninterrupted.

The CUPN Ozone Foliar Injury Program is designed to provide a network-wide assessment of status and trends in ozone foliar injury levels. All 14 CUPN park units are sampled on a rotational schedule (outlined in [CUPN's ozone concentration and foliar injury protocol](#)).

This brief summarizes the foliar injury data collected in July 2019 at Mammoth Cave National Park (MACA). Additionally, the park and its cooperators collect ozone concentration data and data for the 2019 growing season are presented. Ozone foliar injury reports are available upon request at <https://www.nps.gov/im/cupn/index.htm>.

Two foliar injury surveys were conducted at the Great Onyx Job Corps site in the northwestern portion of the park (see map, Figure

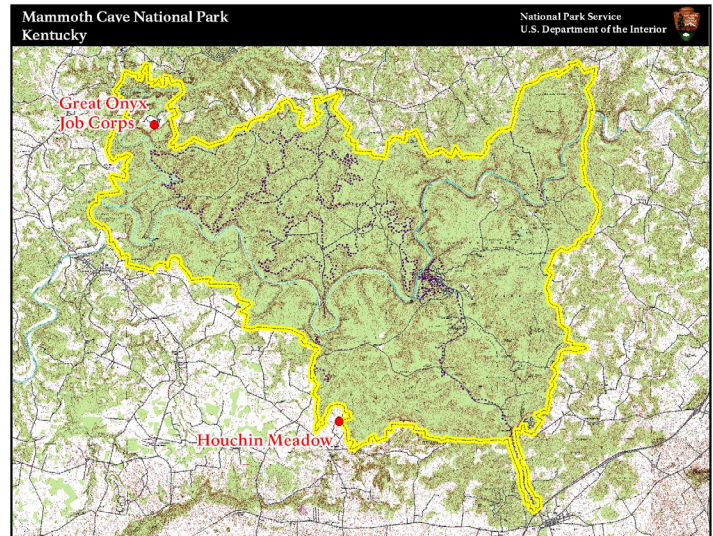


Figure 1. Map of MACA ozone concentration and foliar injury sites. NPS / Lillian Scoggins.

1). One survey was conducted by the principal investigator and one independently and simultaneously by a fellow CUPN employee. The second survey was completed as quality assurance/quality control (QA/QC) for the first survey. In both cases, ozone sensitive plants were examined along the mowed boundary of the field (Figure 2). The elevation of the site is about 650 feet (198 meters).



Figure 2. Great Onyx Job Corps foliar injury site. NPS / CUPN.

Overview (continued)

Ozone concentration data are collected at the Mammoth Cave air quality site at Houchin Meadow. Located near the park’s western boundary (see map, Figure 1), Houchin Meadow is the primary air quality site within Mammoth Cave operated by the park and its cooperators. The on-site ozone analyzer is an Environmental Protection Agency (EPA)-equivalent method (EQOA-0880-047), so data are of sufficient quality to be used for permit review. The relatively low elevation of the site (774 feet or 236 meters) should result in higher concentrations during the day and lower concentrations at night.

Significant Findings

Foliar Injury

In 2019, 801 plants at four CUPN parks were inspected for foliar injury. Of the 179 plants examined at Mammoth Cave National Park, two were suspected to have foliar injury (one was subsequently confirmed to have ozone injury and the other as “maybe”). The principal investigator examined 94 plants and the QA/QC sampler examined 85 plants. It is likely some plants were examined by the principal investigator and the QA/QC sampler, thus the number of unique plants examined was between 94 and 179.

Foliar injury surveys were conducted at Mammoth Cave National Park on July 25, 2019. The results are found in Table 1.

Ozone Concentrations

The National Ambient Air Quality Standard for ozone is set by the EPA. Two standards exist; the “primary standard” is designed to be protective of human health while the “secondary standard” is protective of human welfare.

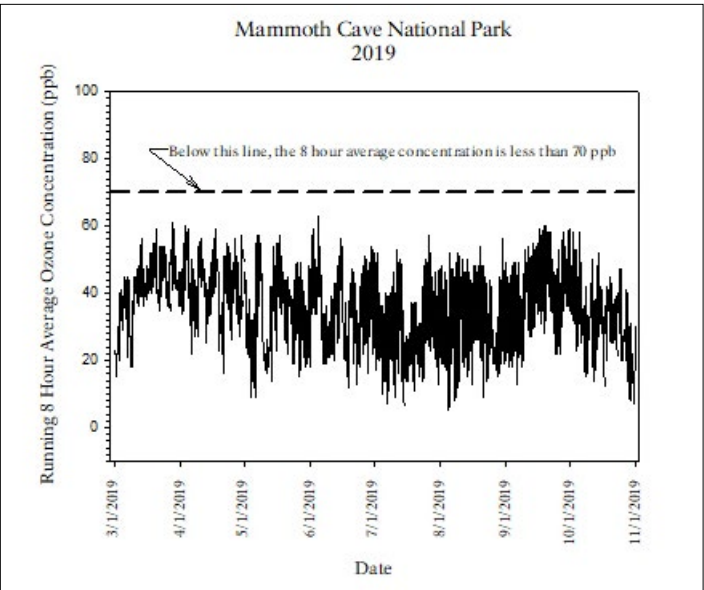


Figure 3. Running 8-hour average ozone concentration at Mammoth Cave National Park.

The primary standard uses a metric defined by the EPA as the “annual fourth-highest daily maximum 8-hour concentration.” In 2019, EPA’s value for the primary standard was 70 parts per billion (ppb), and measurements over that value are considered a violation of the standard. At Mammoth Cave National Park in 2019, the measured fourth-highest daily maximum 8-hour average was 60, in the 54–71 ppb range considered “fair” by NPS-Air Resources Division (ARD). A time series of the 8-hour average in 2019 is in Figure 3.

Research suggests many plant species are more sensitive to ozone than humans. Exposure to ozone is also cumulative in plants; the more the plant is exposed, the greater the injury to the plant.

Table 1. Results of foliar injury surveys at Mammoth Cave National Park in 2019.

Site Name	Species	Scientific Name	Number of Plants Inspected	Injury Confirmed Status?	Number of Plants with Observed Injury
Great Onyx Job Corps / Primary	Dogbane	Apocynum spp.	9	N/A	0
Great Onyx Job Corps / Primary	Milkweed	Asclepias spp.	30	Yes	1
Great Onyx Job Corps / Primary	Sweetgum	Liquidambar styraciflua	23	N/A	0
Great Onyx Job Corps / Primary	Sourwood	Oxydendrum arboreum	1	N/A	0
Great Onyx Job Corps / Primary	Blackberry	Rubus spp.	30	N/A	0
Great Onyx Job Corps / Primary	New York Ironweed	Vernonia spp.	1	N/A	0
Great Onyx Job Corps / QAQC	Dogbane	Apocynum spp.	1	N/A	0
Great Onyx Job Corps / QAQC	Milkweed	Asclepias spp.	30	N/A	0
Great Onyx Job Corps / QAQC	Ash	Fraxinus spp.	2	N/A	0
Great Onyx Job Corps / QAQC	Sweetgum	Liquidambar styraciflua	17	Maybe	1
Great Onyx Job Corps / QAQC	Black Cherry	Prunus serotina	1	N/A	0
Great Onyx Job Corps / QAQC	Blackberry	Rubus spp.	30	N/A	0
Great Onyx Job Corps / QAQC	Pin Cherry	Prunus pensylvanica	1	N/A	0
Great Onyx Job Corps / QAQC	New York Ironweed	Vernonia spp.	3	N/A	0

Significant Findings (continued)

EPA's secondary standard is set to be protective of human welfare, part of which is our need for and enjoyment of plants. Currently, that standard uses the same metric as the primary standard. Many scientists argue W126 would be a better metric. 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 preferentially weights the higher ozone concentrations most likely to affect plants and sums all the weighted concentrations during daylight hours. The highest three-month period that occurs during the growing season is reported in "parts per million-hours" (ppm-hrs). At Mammoth Cave National Park in 2019, the W126 was 4.5 ppm-hrs, in the 0–7 ppm-hrs range of W126 values considered by NPS-ARD to be "good" to protect most sensitive trees and vegetation.

Future Monitoring

Ozone concentration is measured throughout the year by Mammoth Cave National Park and NPS Air Resources Division. The Cumberland Piedmont Network conducts foliar injury sampling on an annual basis at the park.

About the Cumberland Piedmont Network

In 1999 the National Park Service initiated a long-term ecological inventory and monitoring program in more than 280 National Park Service units. This program monitors fundamental elements and processes in park ecosystems to help indicate the overall health or condition of park resources. Data generated allows us to better understand natural processes and the results of management actions, and help guide parks in the successful protection and use of park resources. Information gathered is shared widely through the production of technical reports, resource briefs, and journal publications.

The Cumberland Piedmont Inventory and Monitoring Network, one of 32 networks across the country, includes 14 parks that share geographic proximity and common natural resources. Parks within each of the networks work together to plan, design, and conduct inventories and long-term monitoring. The Cumberland Piedmont Network provides long-term monitoring for water quality, cave bats, crickets and meteorology, Allegheny woodrats, forest vegetation, ozone foliar damage, and invasive species.

For More Information

CUPN Home Page:

<https://www.nps.gov/im/cupn/index.htm>

CUPN Reports & Publications:

<https://www.nps.gov/im/cupn/reports-publications.htm>

About the NPS Inventory & Monitoring Program:

<https://www.nps.gov/im/index.htm>

Data Downloads via the Natural Resource Information Portal:

<https://irma.nps.gov/Portal/>