

Cumberland Piedmont Network

National Park Service
Inventory and Monitoring Division



Standard Operating Procedure 7

Data Analysis and Reporting—Version 2.0

Please cite this as:

Cumberland Piedmont Network. 2024. Ozone and Foliar Injury Monitoring. Data analysis and Reporting—Version 2.0. Standard Operating Procedure. NPS/CUPN/SOP—7. Cumberland Piedmont Network, Mammoth Cave, Kentucky.

Summary

This standard operating procedure (SOP) outlines how Cumberland Piedmont Network foliar injury monitoring data are analyzed and reported. The tasks described in this SOP cover the time **from** when all digital data have been uploaded to the designated folders on the network’s server; all data from the field forms have been entered into the database; and all data verification, validation, and certification steps have been completed **through** report writing. The steps for data handling and processing **prior to** data analysis and reporting are detailed in SOP 5 *Post-Sampling—Version 2.0* (CUPN 2024a) and SOP 6 *Data Management and Quality Assurance/Quality Control—Version 2.0* (CUPN 2024b).

Revision Log

Revision Date	Author	Changes Made	Reason for Change	New Version #
July 2020	Johnathan Jernigan	Updated and included more details on what analysis and reporting consists of.	It was necessary to update this SOP due to substantive changes to our methods and analyses since version 1.0 of the protocol.	2.0

Data Analysis

The monitoring questions and subsequent analysis of the supporting data address issues related to the status of foliar injury in CUPN parks. The protocol was designed to answer the following monitoring questions:

- Are ozone concentrations high enough to cause foliar injury?
- At select CUPN parks in any given year, what is the presence (across species and sites), amount, and severity of foliar injury?

We define “intensity” to consist of presence or absence of injury, the amount and severity of that injury when present, and the number of sites and species with some level of injury. Estimates of ozone exposure indices are retrieved from the NPS Air Resources Division’s (NPS-ARD) website, as discussed in a subsequent section of this SOP. A further discussion of exposure indices is found in this protocol’s narrative (Jernigan and Leibfreid 2024) in the section “Computing Exposure Indices.”

The presence, amount, and severity of ozone-caused foliar injury will be addressed using a simple presentation of the data collected, specifically by listing the plants examined and whether injury was suspected and subsequently confirmed as well as their amount and severity indices.

Foliar injury data are retrieved from CUPN’s ozone foliar injury database using built-in data queries. Figure 1 shows the database’s main menu. Clicking on the “Data queries and reports” button launches a window in which the user can define the scope of the query to be run and how to present the results of the query. Analysis of the data is handled by the project lead. Foliar injury data are incorporated into annual briefs that go to the CUPN parks where sampling occurred, and these briefs are archived according to current NPS guidelines. Files created during data analysis and reporting are stored on the CUPN server. These files consist of initial drafts and the final draft of the report with reviewer comments, any files used to generate time series plots for ozone concentration at Mammoth Cave National Park (MACA; SigmaPlot file and raw data file), screen captures of ARD interpolation graphics, and image files of site images and maps. Raw foliar injury data and data derived therefrom will be archived with the report. Inventory and Monitoring Division guidance on the contents of the data package, when it becomes available, will be used to determine the files that will be archived with each report or brief.

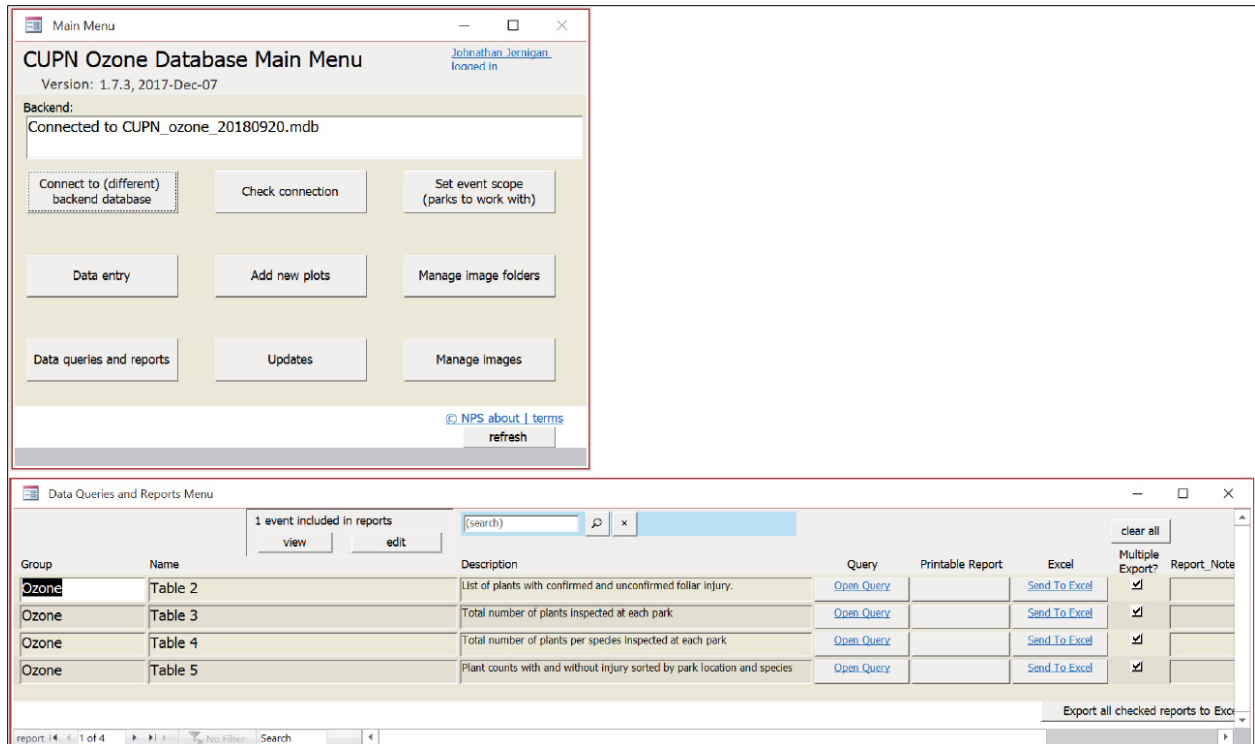


Figure 1. Upper image shows "Data queries and reports" button used to open lowermost window wherein data can be exported for inclusion in reports.

Analysis will be completed annually and will be limited to sorting the data by park, site, species and whether the injury was confirmed or unconfirmed during the subject matter expert's voucher inspection. An example of these data is presented in Table 1. For each species, the total number of plants examined, the number suspected with injury, and whether the injury was confirmed as ozone-caused is presented. At any park where a QA/QC visit was conducted, those data are presented alongside the findings of the non-QA/QC team. These findings are compared to Air Resource Division's interpolated exposure indices and drought severity to ascertain whether the findings, indices, and drought severity appear consistent with one another.

Table 1. Example of how foliar injury data are presented in resource briefs.

Site Name	Species Common Name	Species or Genus Scientific Name	Number Inspected	Number with Injury?	Ozone-Caused?
Sandburg Pasture	Common Milkweed	<i>Asclepias</i> sp.	30	4	Yes
Sandburg Pasture	Swamp Milkweed	<i>Asclepias</i> sp.	2	0	N/A
Sandburg Pasture	Tulip Poplar	<i>Liriodendron tulipifera</i>	6	0	N/A
Sandburg Pasture	Blackberry	<i>Rubus</i> sp.	10	0	N/A
Sandburg Pasture	New York Ironweed	<i>Vernonia</i> sp.	30	0	N/A

Reporting

This section describes the procedure for reporting ozone information, the report review process, and the distribution of completed reports. Efficient reporting on monitoring results is critical in assisting park resource managers with management decisions. Therefore, a reporting schedule is given with key reporting timeframes identified. Timely production of appropriate reports is the responsibility of the project leader and the CUPN program manager. Three kinds of reports will be generated: (1) unpublished trip reports that are sent to park staff within two weeks of sampling, (2) annual resource briefs that will be published in the following calendar year, and (3) multiyear synthesis reports after the end of each six-year cycle.

Trip Reports

Within two weeks of field sampling, the crew leader sends a preliminary summary of the findings at each site within a park to the appropriate park staff. The summary includes, at least, basic information such as site name, date of survey, plant species examined, how many plants of each species were examined, whether any suspected ozone-caused injury was found and (in future reports) the average amount and severity of any injury that was confirmed. An example of a recent trip report is shown in Figure 2.

2018 CUPN Ozone Foliar Injury Survey at MACA

Jernigan, Johnathon W <Johnathon_Jernigan@nps.gov>

Thu 9/20/2018 4:52 PM

To: Trimble, Barclay BCT <Barclay_Trimble@nps.gov>; Pinion, Timothy <Timothy_Pinion@nps.gov>

Cc: Leibfreid, Teresa <Teresa_Leibfreid@nps.gov>; Bledsoe, Clare F <Clare_Bledsoe@nps.gov>

Hi All,

I just wanted to summarize the results of the foliar injury survey at MACA on August 9, 2018. We conducted a foliar injury assessment at the following site:

MACA - Great Onyx Job Corps

Using plants that are sensitive to ozone, we visually inspected plant leaves for the injury caused by ozone. Often, we find injury that we suspect is caused by ozone. This year, however, we found nothing. Had injury been found, we would have collected as many as three voucher leaves (per species) that would have been placed in a plant press. These voucher specimens would have been sent to a regional expert to verify that the damage we claimed to be ozone injury was actually ozone injury. When the regional expert had completed the verification, the specimens would have been returned to the CUPN and the specimens would have been permanently preserved as per the sampled park's instructions. The foliar injury surveys were conducted by Clare Bledsoe (CUPN) and myself (50% NPS Air Resources Division and 50% CUPN). Thanks to Clare for her assistance. Clare and I made independent sweeps of the sites. We sampled some of the same individual plants and each of us sampled some plants that the other did not. A summary of the results of the survey is below.

Park Name	Site Name	Plant Common Name	Scientific Name	Number of Plants Inspected by Johnathon/Clare	Injury Confirmed	Number Of Plants with Observed Injury
MACA	Job Corps	Dogbane	Apocynum sp.	7/15	N/A	0
MACA	Job Corps	Milkweed	Asclepias sp.	30/30	N/A	0
MACA	Job Corps	Ash	Fraxinus sp.	0/2	N/A	0
MACA	Job Corps	Sweetgum	Liquidambar styraciflua	7/10	N/A	0
MACA	Job Corps	Wild Black Cherry	Prunus serotina	0/1	N/A	0
MACA	Job Corps	Winged Sumac	Rhus copallinum	1/0	N/A	0
MACA	Job Corps	Blackberry	Rubus sp.	30/30	N/A	0

Any questions or comments, please let me know. Thanks so much.
Johnathon

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Figure 2. Example of a trip report.

Annual Resource Briefs

The summary of findings discussed in the data analysis section of this SOP is presented in annual resource briefs for each park. The data (park, site, species and whether the injury was confirmed or unconfirmed during the subject matter expert's voucher inspection) are presented in tabular form within annual briefs. A cursory review of these tables will provide the answer to the protocol's monitoring questions: is foliar injury occurring at select sites and what is the amount and severity of that injury? Additionally, basic site information, photographs and maps are presented and discussed, especially parameters such as site elevation (which can influence the concentration of ozone available for dosing plants) and drought severity at the time of the injury survey (which can affect

plant intake of ozone). Site elevation data are collected while at each site using a GPS unit. Drought severity sources and indices that best suit our analyses have not yet been determined and will be addressed in subsequent versions of this SOP.

Lastly, ozone exposure indices are discussed. NPS Air Resources Division has available tables with interpolated exposure indices from recent years for NPS park units at [NPS Air Quality Conditions and Trends](https://www.nps.gov/subjects/air/park-conditions-trends.htm) (<https://www.nps.gov/subjects/air/park-conditions-trends.htm>). An example of ARD's interpolated data is shown in Figure 3. Screen captures of ARD's graphics are presented in the resource briefs and stored in the brief's directory with all other supporting materials. At Mammoth Cave National Park, interpolated data are unnecessary since that park has its own continuous ozone concentration monitor. Those data are downloaded from a contractor's website or by contacting the contractor directly and requesting the data. Since contracts with this subcontractor are regularly reevaluated, and subcontractors can change over time, the specifics of data access methods will not be discussed because they are subject to frequent change. These data are stored in the resource brief's directory with all other supporting materials for the brief.

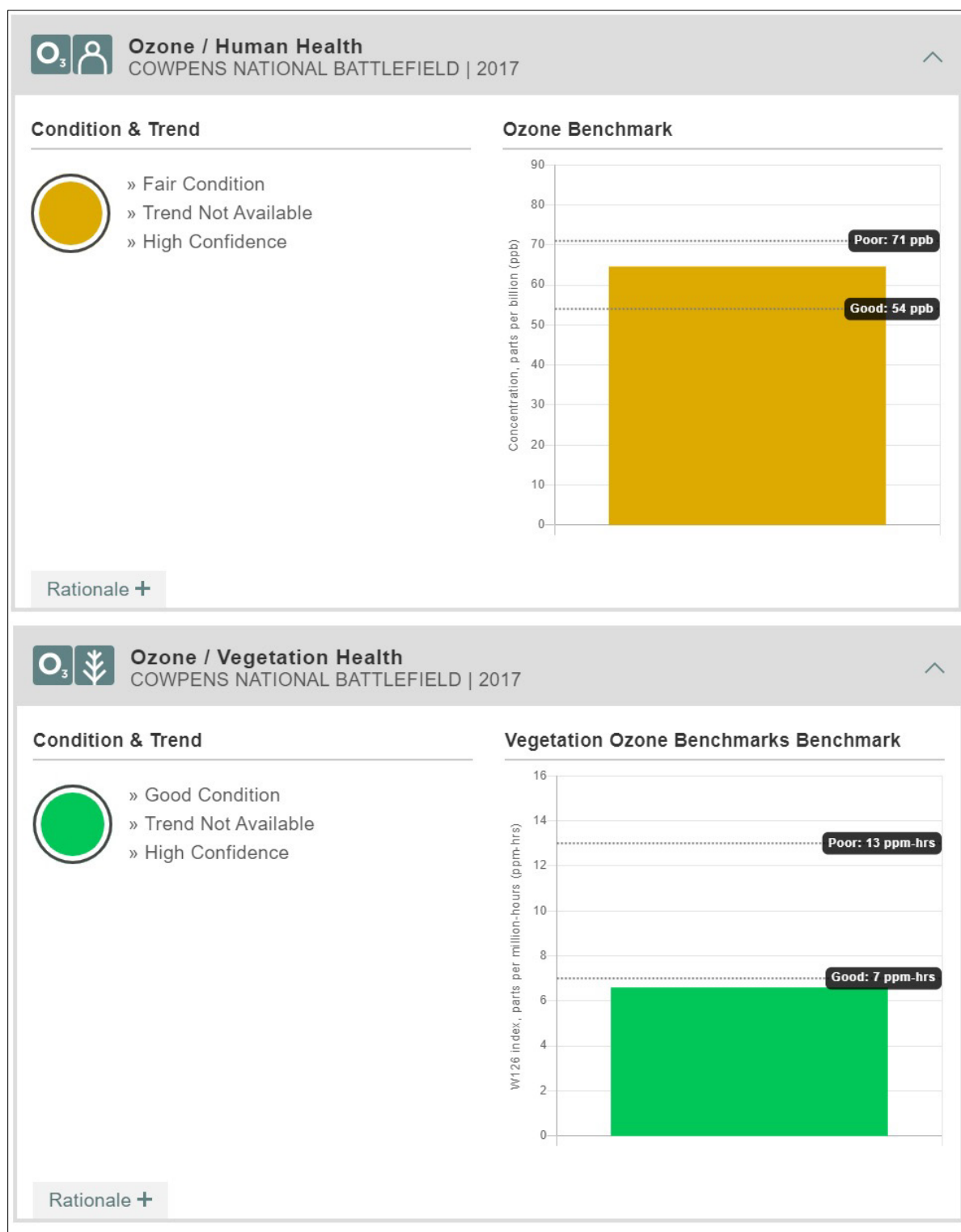


Figure 3. Example of interpolated ozone exposure indices downloaded from the NPS Air Resources Division.

Interrelationships between all data collected will also be discussed, such as:

- Given the ozone exposure indices and drought severity, is the presence, amount, and severity of injury found by the Cumberland Piedmont Network to be expected?

These discussions are presented at the end of the brief. An example resource brief is shown in Figure 4.

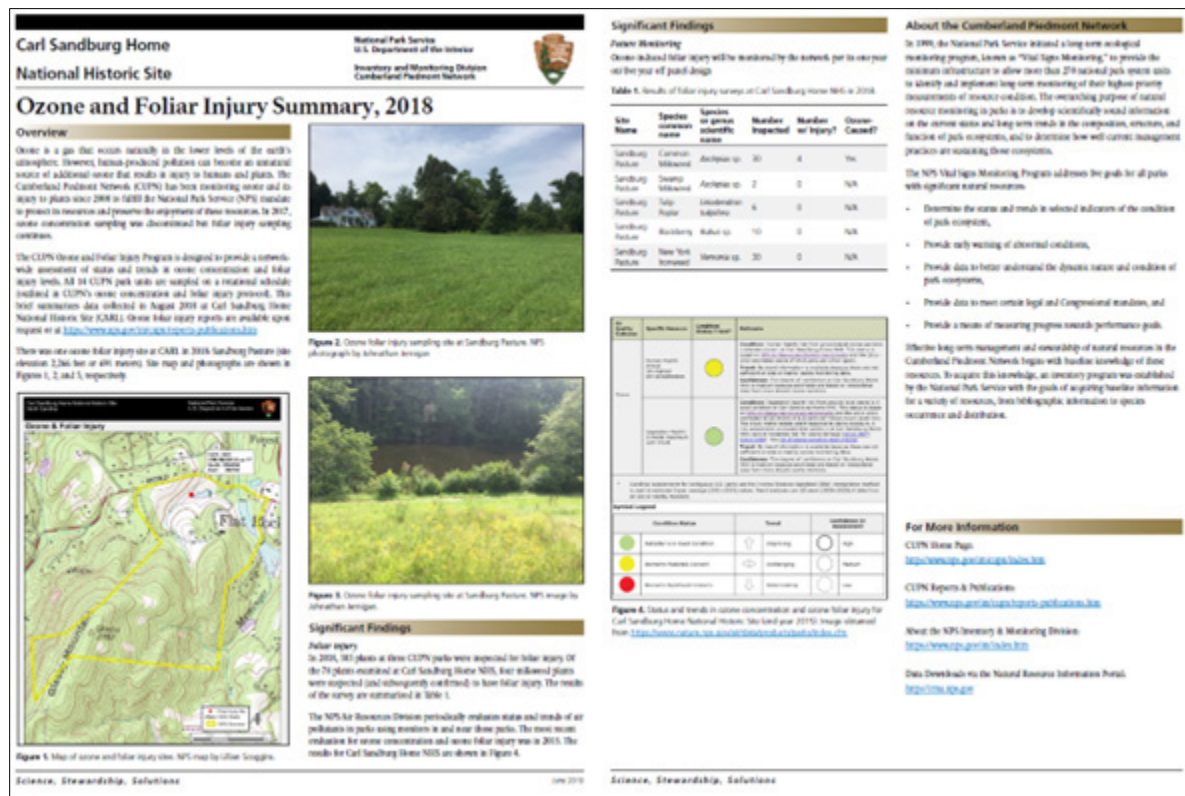


Figure 4. Example of annual resource brief.

Synthesis Reports

As of the writing of version 2.0 of this SOP, the Cumberland Piedmont Network has not produced a synthesis report associated with this ozone and foliar injury protocol. However, the authors would like to create such reports in the future. Since this protocol was not designed to evaluate trends in ozone exposure indices or the associated foliar injury to plants, the synthesis reports will likely explore such topics as:

- Trend analysis of presence or absence data of ozone injury on individual plants at Mammoth Cave National Park. Binomial regression models could incorporate ozone index, drought severity, and time as explanatory variables. Species with some level of injury over the sampling period considered can be pooled and binomial regression applied to determine how the probability that a plant expresses ozone symptomology is changing over time. We may also explore whether our data show differences in response among species.

- If increases in amount and severity indices are anecdotally detected, then we may explore whether these increases are statistically significant.
- How CUPN's ozone injury data from its sites compare to NPS-ARD's interpolated ozone exposure indices.
- What role environmental conditions, such as moisture availability, play in how often we confirm foliar injury.
- Whether injury is widespread across multiple species and plants.
- Whether injury is widespread across network parks.

The exact topics and approach to be discussed in synthesis reports will be provided in subsequent versions of this SOP.

Review Procedure

Annual briefs on ozone and foliar injury monitoring are prepared by the project leader using site location maps provided by the GIS Specialist, site photos, and the tables mentioned earlier (see Figure 4 for an example resource brief). Text and images are provided to the technical editing team (based at the University of Georgia) who compile the draft document using a pre-designed template. The next step is internal review by CUPN staff, which will usually consist of the CUPN program manager and two of the CUPN biologists. External review is also completed for any resource brief in which there is any interpretation of the results.

Identifying Stakeholders

The primary stakeholders in our ozone and foliar injury monitoring efforts are the National Park Service management staff at CUPN parks. Potential stakeholders include state and federal wildlife agencies, universities, and the public. Natural resource specialists conducting (or considering conducting) ozone or ozone effects monitoring should also be interested in project results.

Trip reports are sent to appropriate natural resource staff and superintendents at sampled parks, as detailed in CUPN's list of natural resource staff and superintendents, keeping in mind that some superintendents do not wish to be included in such communications. Resource briefs and other reports are forwarded to appropriate natural resource staff at the sampled park as listed in CUPN's list of natural resource staff.

Distributing Reports

As discussed, annual briefs are provided to resource managers at CUPN parks as appropriate. Additionally, a copy is archived according to current NPS guidelines and a hardcopy is kept on file in the project lead's office at Mammoth Cave National Park, Mammoth Cave, Kentucky. Resource briefs and any reports generated are available to all interested parties upon request. Sampled parks are notified when reports are available and hyperlinks or digital copies of the reports are provided by the project lead to appropriate park staff.

All data collected by the Cumberland Piedmont Network is public property and is subject to requests under the Freedom of Information Act (FOIA). Reports containing non-sensitive data are disseminated through the CUPN website and IRMA.

Literature Cited

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[DataStore - Monitoring ozone and associated foliar injury at Cumberland Piedmont Network parks: Protocol narrative—version 2.0 \(nps.gov\)](#)