



Air Quality Monitoring 2019 Annual Report

Sequoia and Kings Canyon National Parks

Natural Resource Report NPS/SEKI/NRR—2020/2141



ON THE COVER

Photograph of the Ash Mountain air quality and meteorological station in Sequoia National Park.
Photograph courtesy of the National Park Service

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Abstract

Sequoia and Kings Canyon National Parks (SEKI) periodically experience the worst air quality in the National Park Service (NPS). Elevated ground-level ozone (O₃) may be the most damaging pollutant in SEKI, when in summer months, concentrations often exceed the federal ozone health standards. The harmful effects of increased O₃ go beyond human health and into park ecosystems, including widespread damage to sensitive vegetation, which could alter how plants grow, produce and store food. From early June to late October 2019, O₃ conditions were [monitored and forecasted to employees and the public](#) from two locations in SEKI: the Ash Mountain air quality station located in the foothills and the Lower Kaweah air quality station in the Giant Forest. During the summer season Ash Mountain measured 60 days exceeding federal health standards for ozone, which is the most out of all other NPS units. Lower Kaweah was third worst across all NPS sites at 28 days.

Acknowledgements

We would like to thank the following individuals for their instrumental participation in making the 2019 Air Quality program operate smoothly: Arianne Sarzotti, Brian Beaty, Danielle Shaffer, and the many volunteers and SEKI colleagues who've provided a helping hand in a variety of tasks.

Summary of Air Quality Monitoring

Sequoia and Kings Canyon National Parks (SEKI) periodically experience the worst air quality in the National Park Service. Elevated ground-level ozone (O₃) may be the most damaging pollutant in SEKI, when in summer months, concentrations often exceed the federal ozone health standards of greater than 70 parts per billion (ppb) averaged over an 8 hour (h) period. Ozone is a secondary pollutant, formed when nitrogen oxides (NO_x) and volatile organic compounds (VOCs) combine with warming temperatures and sunlight. Above 70 ppb, ozone may have negative health effects particularly for sensitive groups, such as children, older people, and those with heart or lung disease (Table 1). As O₃ increases, others beyond sensitive groups may be affected (EPA 2020). Examples of ozone health effects include chest pain, coughing, throat irritation, congestion, and exasperation of bronchitis, emphysema, and asthma. The harmful effects of increased O₃ go beyond human health and into park ecosystems, including widespread damage to sensitive vegetation, which could alter how plants grow, produce and store food.

From early June to late October 2019, O₃ conditions were monitored and forecasted to employees and the public from two locations in SEKI: the Ash Mountain air quality station located in the foothills and the Lower Kaweah air quality station in the Giant Forest (Thermo TECO 49/49C Inst.; Figure 1). Daily ozone Air Quality Index (AQI) levels were forecasted through an internet-linked automated process that summarizes ozone and meteorology data from each station from the prior day, as well as expected conditions from weather forecasts. The forecasts are then made available through Twitter Inc. (@SequoiaKingsAir) and embedded for greater outreach through the SEKI Air Advisory website (NPS 2020b). At the end of each advisory season, validated data is downloaded from NPS Gaseous Pollutant and Meteorological Data Access Page, and graphics are generated using the OpenAir package in R Statistical Software (Carslaw and Ropkins 2012, R Software 2019).

From April to October 2019, the Ash Mountain site measured 60 days exceeding federal health standards (Figure 1). This was the most of any NPS unit and was followed by the Black Rock station in Joshua Tree N.P. (38 days), the Lower Kaweah station in SEKI (28 days), and the Kelso Mountains station in Mojave National Preserve (19 days). All other NPS O₃ stations measured 6 days or less exceeding federal health standards (NPS 2020a). Air quality was poor in SEKI compared to most other NPS sites, despite the total number of ozone exceedance days at Ash Mountain showing an annual decrease since 2016. During the SEKI advisory forecast season (June through October) in Ash Mountain, August had the highest number of days at the Unhealthy for Sensitive Groups level or higher (Figure 2, Figure 3). At Lower Kaweah during the advisory season, August also had the highest number of days at the Unhealthy for Sensitive Groups level or higher (Figure 4, Figure 5). Wind speed and wind direction influenced ozone concentration levels at both the Ash Mountain and Lower Kaweah sites (Figure 6, Figure 7).

Particulate matter (PM_{2.5}) was also monitored for a portion of the year in Ash Mountain (BAM 1020, E-BAM Inst.). Due to the prominence of invalid data, we were only able to retrieve hourly PM_{2.5} concentrations for September through December 2019. For a more extensive look at air quality conditions in 2019, please refer to Figures 8 through 10.

Table 1. Air quality index developed by the EPA to protect public health. More stringent AQI breakpoints were changed on Oct. 1, 2015. For SEKI and the region, this has resulted in several more days in AQI levels “Unhealthy for Sensitive”.

Air Quality Index	PPB	Health Concern
Good (0-50)	(0-54)	None
Moderate (51-100)	(55-70)	Unusually sensitive people should consider reducing prolonged or heavy exertion
Unhealthy for Sensitive Groups (101-150)	(71-85)	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.
Unhealthy (151-200)	(86-105)	People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion.
Very Unhealthy (201-300)	(106+)	People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.

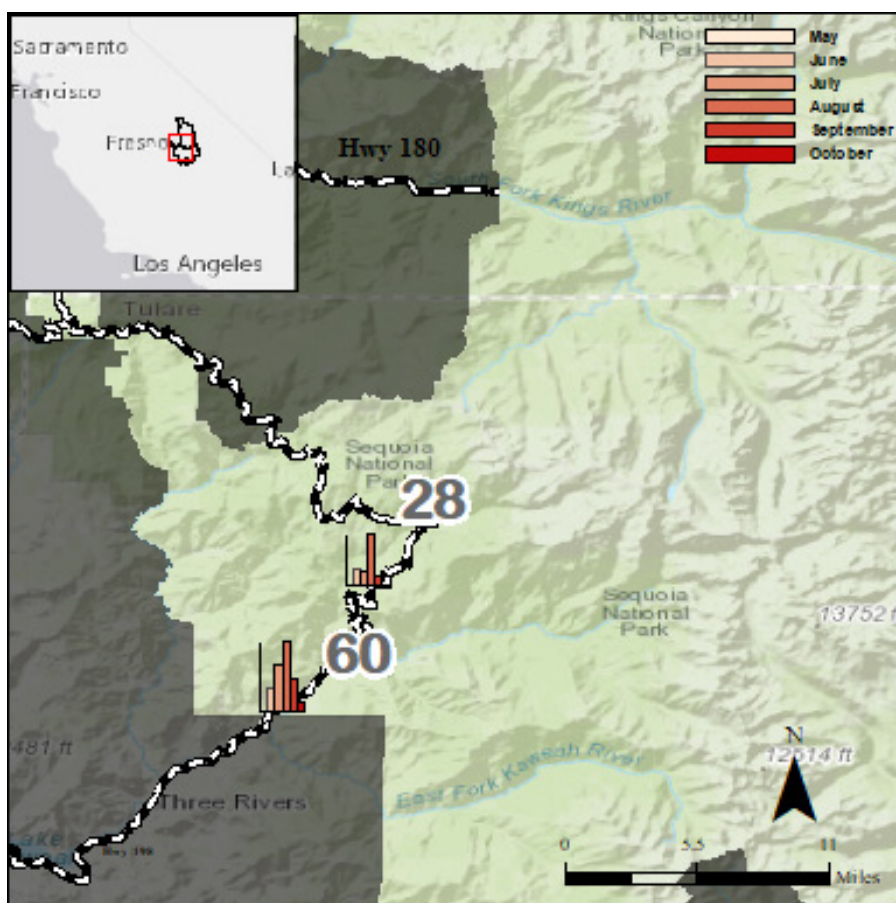


Figure 1. Location of monitoring sites depicting total number of exceedance days during the 2019 SEKI ozone (O_3) forecast season (June-Oct.). This pollution benchmark includes days where O_3 exceeds 70 ppb over an 8 hour average, totaled by season (dark grey) and month (column chart).

Ash Mountain Ozone Calendar 2019

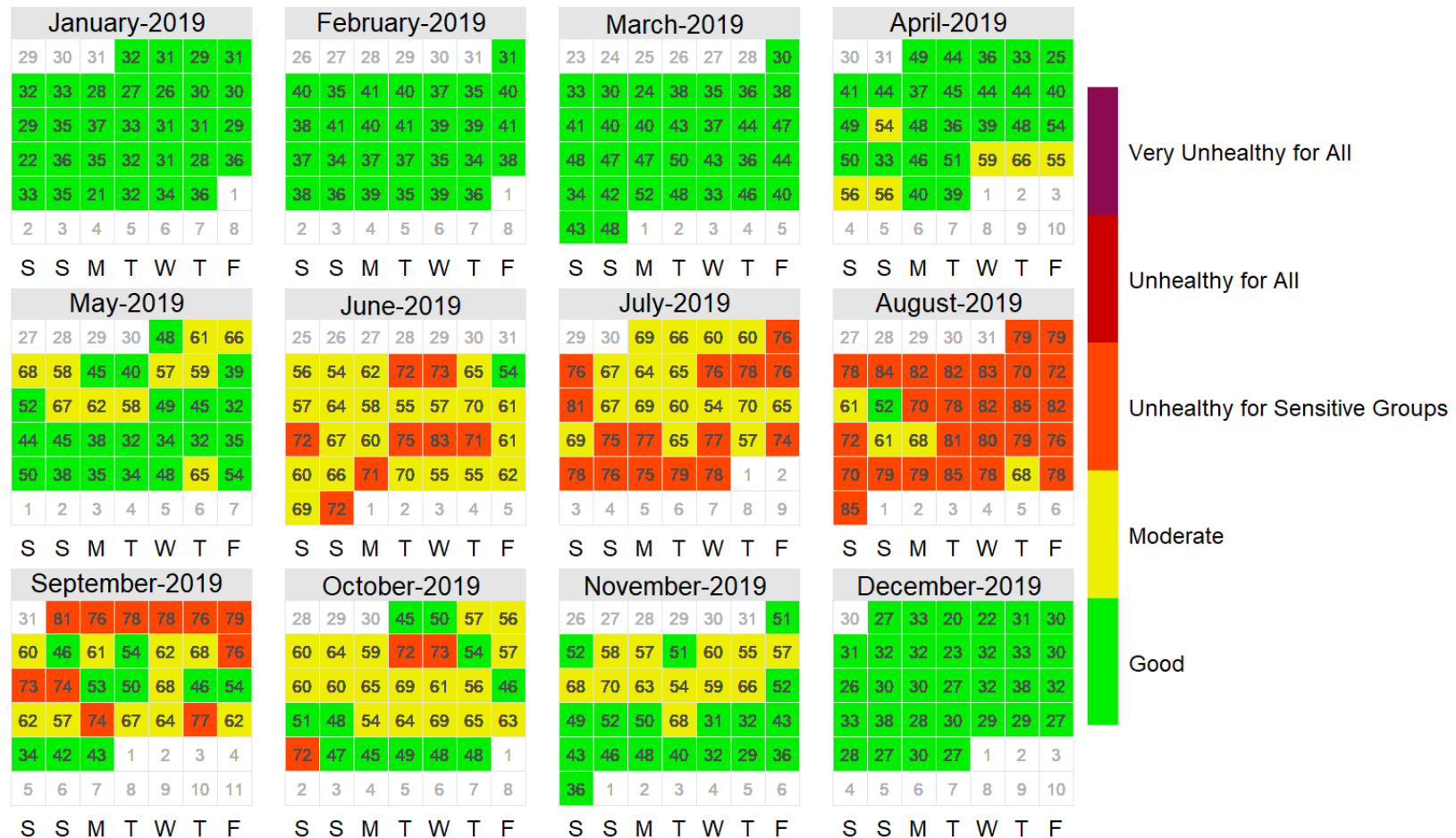


Figure 2. Calendar plot for O₃ concentrations at Ash Mountain. Each day of the month depicts the maximum O₃ 8-hr concentration and the corresponding AQI health level.

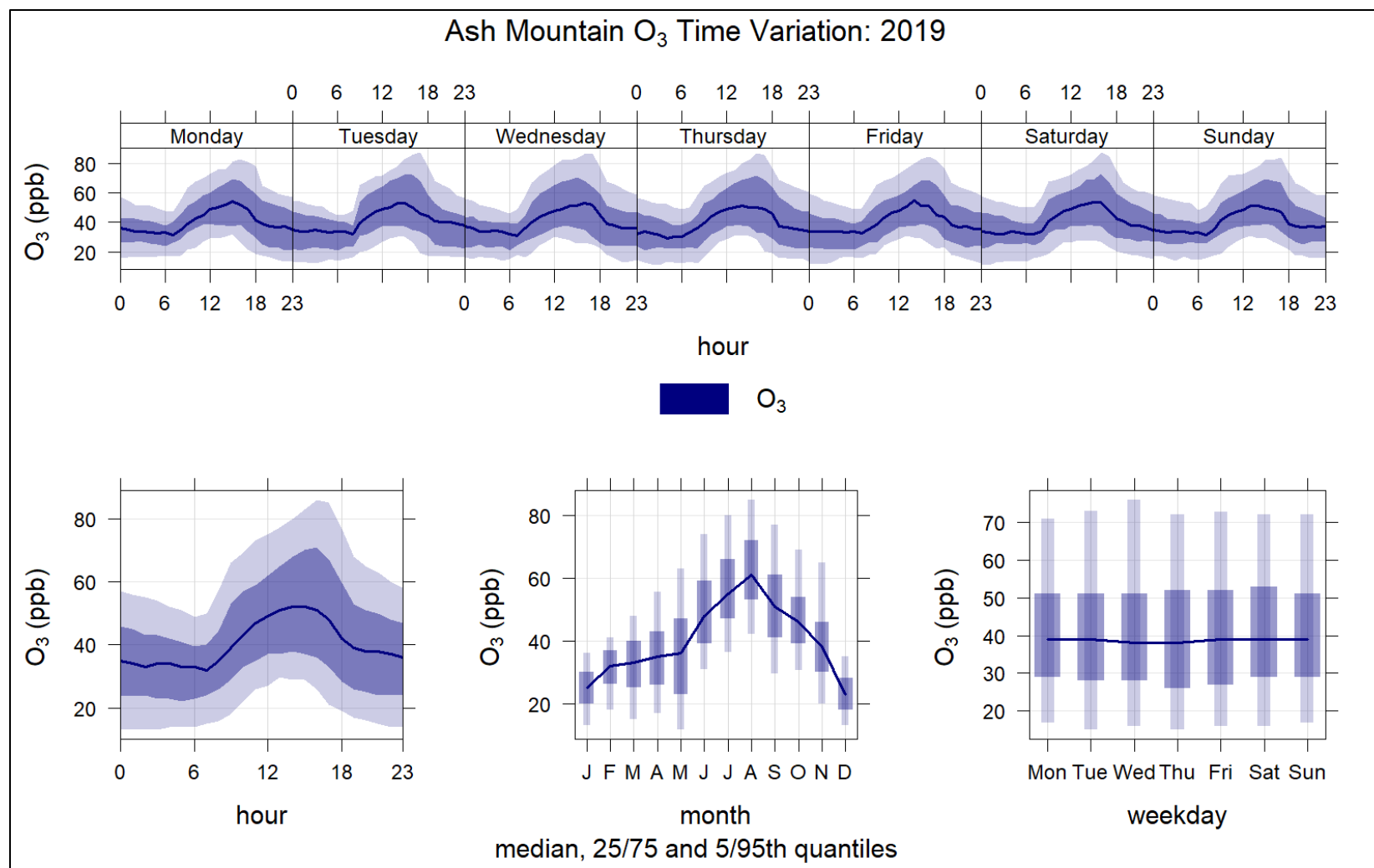


Figure 3. Time variation plot of median hourly O₃ concentrations at Ash Mountain. The purpose of a time variation plot of a pollutant can reveal prominent time of day, day of week, and monthly trends. In 2019 at Ash Mountain, median O₃ concentrations were the highest in the afternoons. The best months for O₃ were from November through April, and the highest concentrations were from May through October.

Lower Kaweah Ozone Calendar 2019

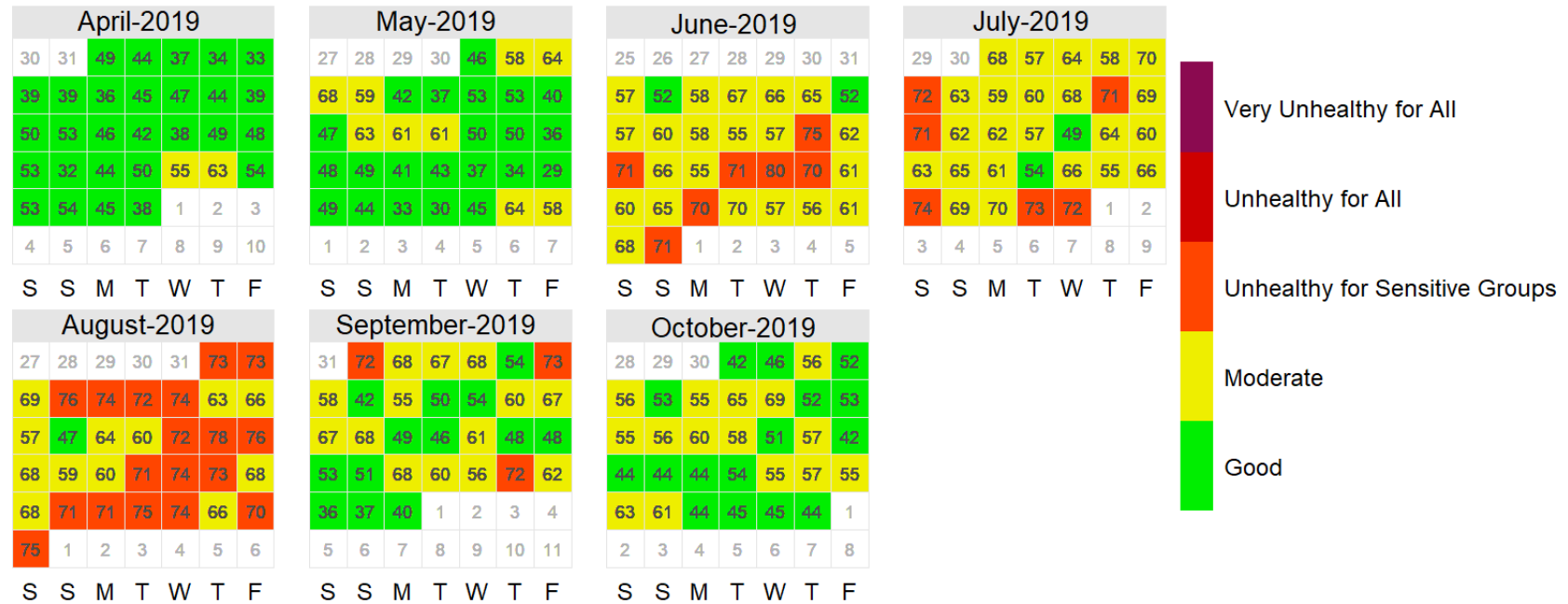


Figure 4. Calendar plot for O₃ concentrations at Lower Kaweah. Each day of the month depicts the maximum O₃ 8-hr concentration and the corresponding AQI health level. The Lower Kaweah station is maintained all year, but the data is only validated and made public May – November

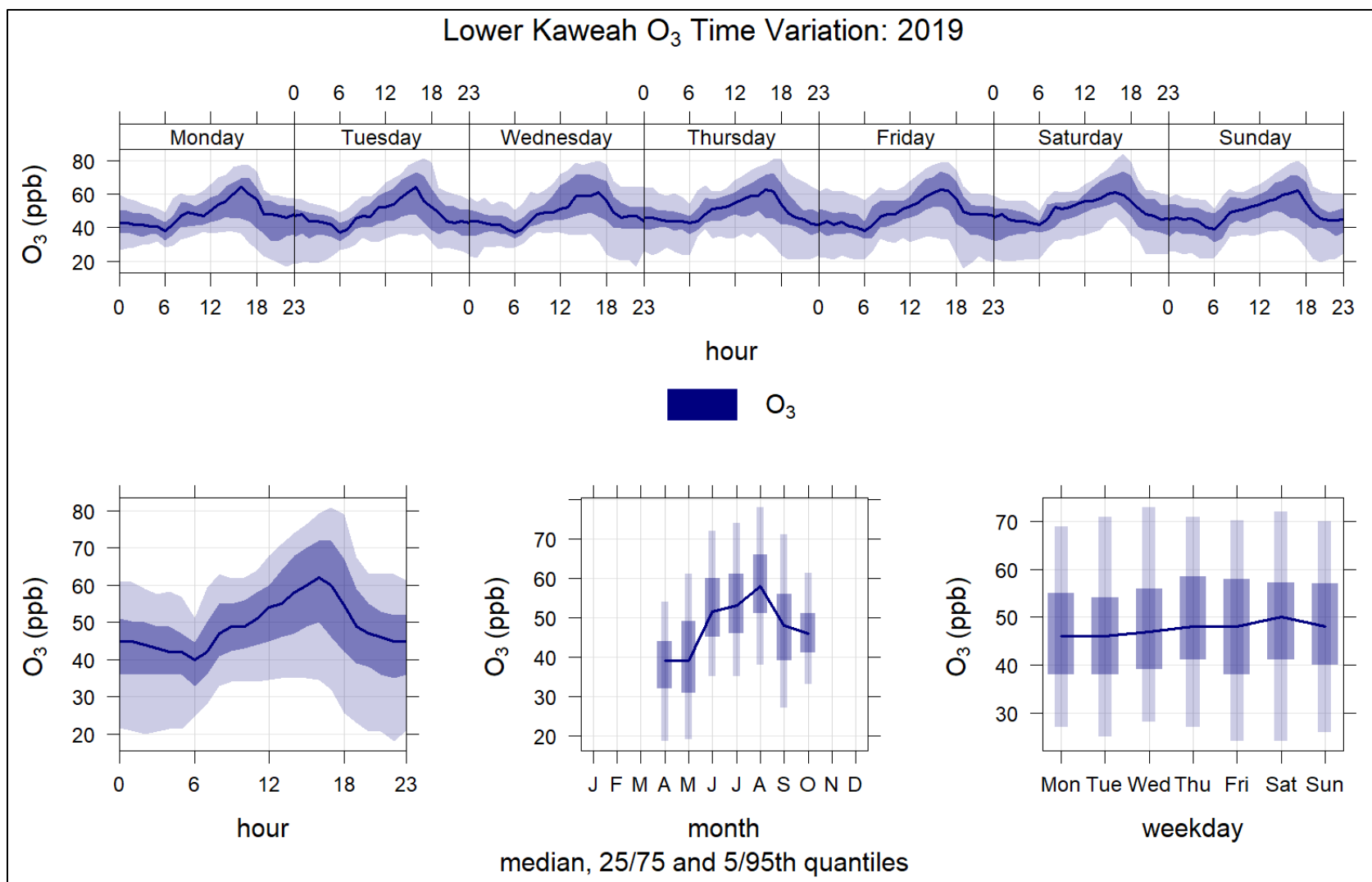


Figure 5. Time variation plot of median hourly O₃ concentrations at Lower Kaweah. The purpose of a time variation plot of a pollutant can reveal prominent time of day, day of week, and monthly trends. In 2019 at Lower Kaweah, median O₃ concentrations were the highest in the afternoon and early evening, and each weekday throughout the year. The best months for O₃ were from November through May, and the highest concentrations were from June through September. Note that this station only operates seasonally (May-November).

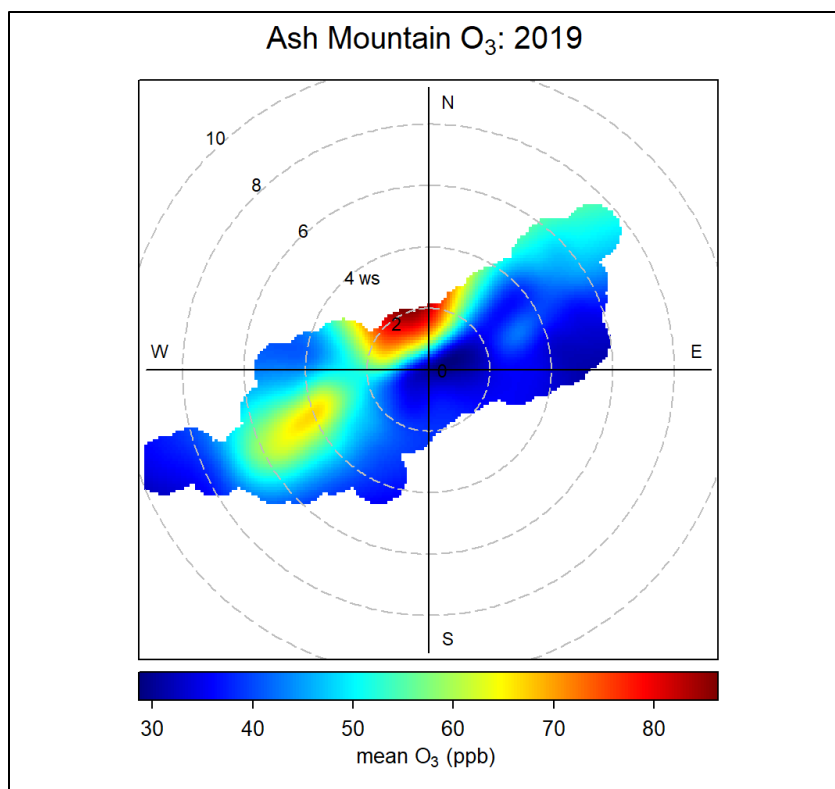


Figure 6. Polar plot of mean hourly O₃ concentrations at Ash Mountain. The polar plot function depicts how O₃ concentration varies by wind direction and wind speed. In 2019 at Ash Mountain, O₃ was higher at low wind speeds (< 2 m/s) coming from the north-west, and slightly north-east. O₃ decreased at higher wind speeds coming from the east.

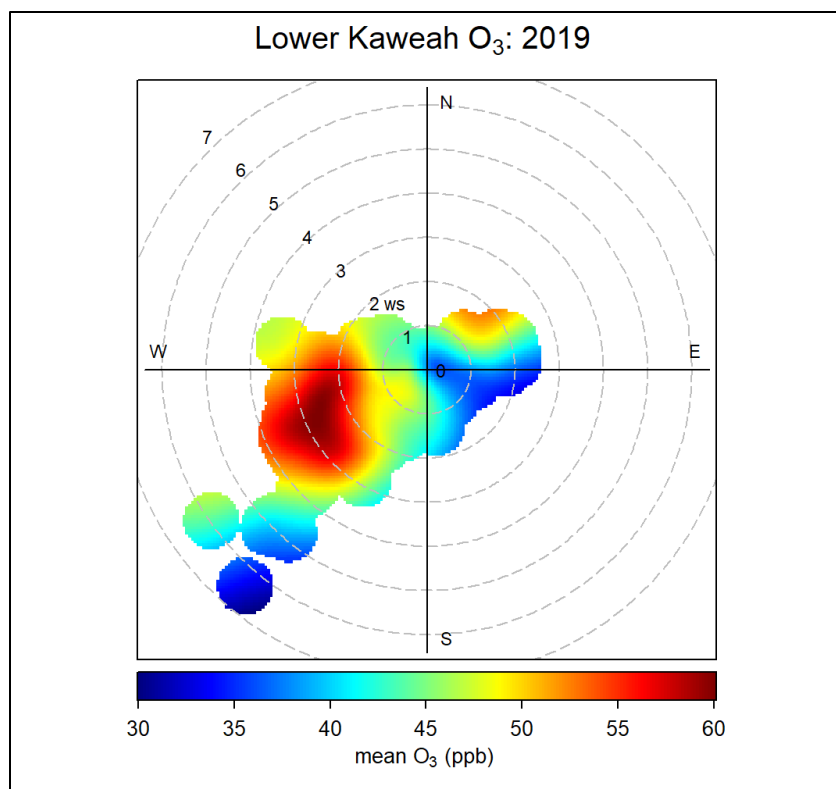


Figure 7. Polar plot of mean hourly O₃ concentrations at Lower Kaweah. The polar plot function depicts how O₃ concentrations vary by wind direction and wind speed. In 2019 at Lower Kaweah, O₃ increased at higher wind speeds (2-4 m/s) coming from the south-west. O₃ was decreased at lower wind speeds (0-3 m/s) coming from the south-east.

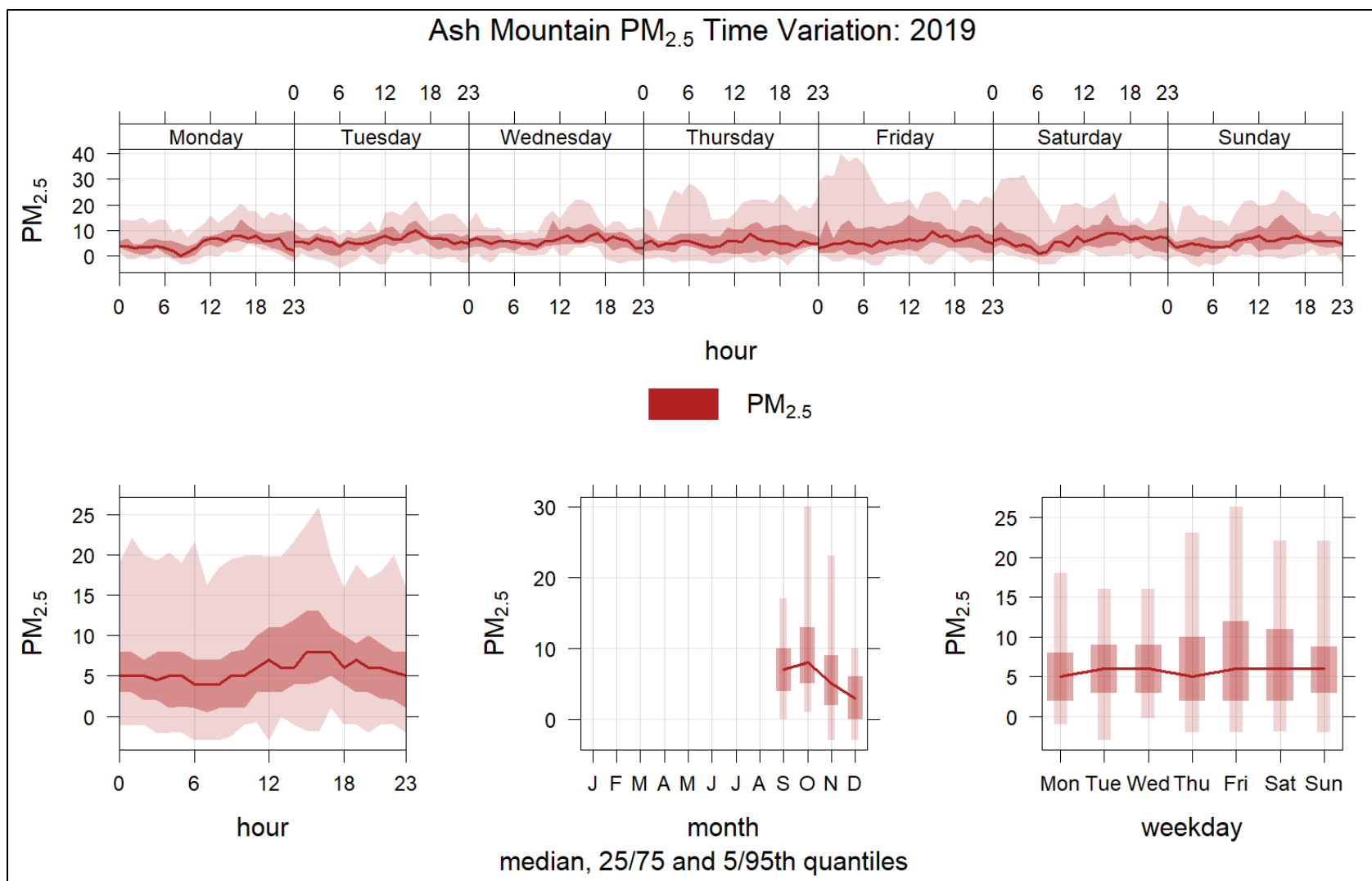


Figure 8. Time variation plot of median hourly PM_{2.5} concentrations at Ash Mountain. The purpose of a time variation plot of a pollutant can reveal prominent time of day, day of week, and monthly trends. In 2019 at Ash Mountain, median PM_{2.5} concentrations were highest in the afternoons throughout the year. Data is limited to September through December 2019. Based on this limited dataset the highest concentrations were in October.

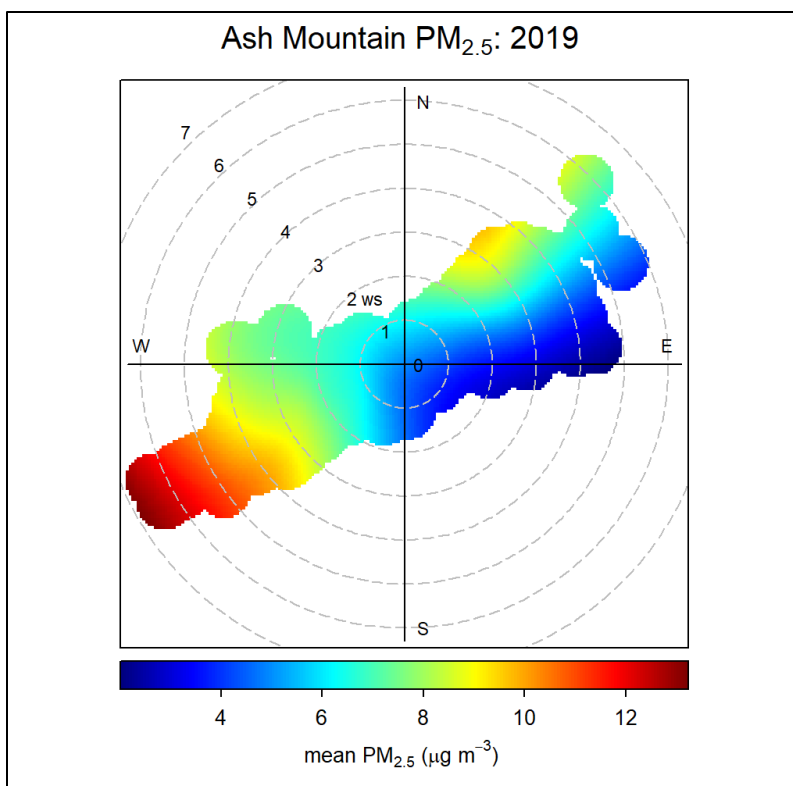


Figure 9. Polar plot of mean hourly PM_{2.5} concentrations at Ash Mountain. The polar plot function depicts how PM_{2.5} concentrations vary by wind direction and wind speed. In 2019 at Ash Mountain, PM_{2.5} was highest when wind was 4-7 m/s coming from the south-west. PM_{2.5} decreased at low to high easterly winds.

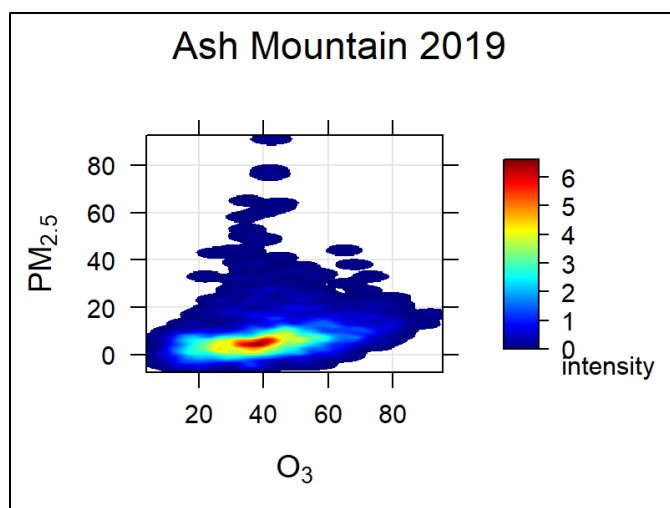


Figure 10. Scatter plot of hourly PM_{2.5} vs. O₃ at Ash Mountain using a kernel density estimate to show where most of the points lie. The darker red intensity indicates the most common relationship between the two pollutants. In 2019, PM_{2.5} and O₃ were commonly found together at low concentrations, well within the “Good” AQI level for each. At higher PM_{2.5} concentrations, O₃ was typically low, and at the highest O₃ concentrations, PM_{2.5} was also low.

SEKI Air Advisory Program QA/QC

Each year, the effectiveness and accuracy of SEKI forecasts are evaluated. In 2019, we continued forecasting from our website. Our website (<https://www.nps.gov/seki/learn/nature/airqualityinfo.htm>) resulted in 3,700 unique visits in 2019. We also have a short url that is commonly used and likely results in many more visits, but we are unable to quantify how many.

To evaluate the accuracy of SEKI's daily AQI forecasts, we compared our predicted calls with the actual conditions (Table 2). In 2019, SEKI was correct 61% of the time when forecasting the foothills (via Ash Mountain data) and 65% of the time forecasting the middle elevations (via Lower Kaweah data) of the parks. SEKI's forecast accuracy dropped from 2018. This was especially apparent at both Ash Mountain and Lower Kaweah when the actual AQI condition was considered "Good," and we forecasted higher. Forecasting higher than the actual AQI condition occurred more frequently than forecasting lower.

Table 2. Forecast accuracy for SEKI during the 2019 forecast season. Represented is the percentage of correct calls at each AQI level. Also included are the percentages of incorrect forecasts and the proportion of those that were forecasted higher or lower than the actual condition. Ozone concentrations did not reach "Unhealthy for All" at Ash Mountain or Lower Kaweah in 2019.

Forecaster	Actual AQI Condition	Ash Mountain			Lower Kaweah		
		Correct	Forecasted Higher	Forecasted Lower	Correct	Forecasted Higher	Forecasted Lower
SEKI	Across all AQI levels	61%	24%	15%	65%	21%	14%
	When Unhealthy for All	N/A	N/A	N/A	N/A	N/A	N/A
	When Unhealthy for Sensitive	70%	3%	27%	71%	0%	29%
	When Moderate	54%	37%	9%	71%	17%	12%
	When Good	50%	50%	N/A	33%	67%	N/A

SEKI Air Program: What else do we do?

In addition to monitoring for O₃, SEKI air quality sites operate within several nationwide air pollutant monitoring networks. This requires collection and maintenance of a variety of pollutants, which are used to determine status and trends of air quality conditions both locally and nationally (Table 3).

Table 3. Monitoring networks and pollutants measured in SEKI.

Air Monitoring Programs	Visibility	Ozone & Meteorology	Wet & Dry Deposition
Network Names	IMPROVE (Interagency Monitoring of Protected Visual Environments)	GPMN (Gaseous Pollutant Monitoring Network)	Wet: NADP (National Atmospheric Deposition Program) Dry: CASTNET (Clean Air Status and Trends Network)
Parameters Measured	fine and coarse particle (PM2.5 & PM10) mass, elements, sulfate, nitrate, organic and elemental carbon, scenic views, scattering, and absorption	ozone, wind speed, wind direction, ambient temperature, relative humidity, solar radiation, precipitation	Wet: pH, sulfate, nitrate, ammonium, major anions and cations (NTN network), and mercury in precipitation (MDN network) Dry: sulfur dioxide, sulfate, nitric acid, nitrate, and ammonia (AMON network);
Frequency of Measurements	24-hrs every 3 days	continuous, hourly averages	weekly
Access to Data	Visibility Data	Ozone & Met Data	Wet Deposition Data & Dry Deposition Data

Literature Cited

- Carslaw, D. C. and K. Ropkins. 2012. openair --- an R package for air quality data analysis. Environmental Modelling & Software. Volume 27-28, 52-61.
- National Park Service (NPS). 2020a. NPS Ozone Standard Exceedance website. Available at: <https://www.nps.gov/subjects/air/ozone-exceed.htm> (accessed 11 March 2020).
- National Park Service (NPS). 2020b. NPS SEKI Air Quality Information website. Available at: <https://www.nps.gov/seki/learn/nature/airqualityinfo.htm> (accessed 11 March 2020).
- National Park Service (NPS). Access to Gaseous Pollutant and Meteorological Data website. Available at: <http://ard-request.air-resource.com/> (accessed 11 March 2020).
- United States Environmental Protection Agency (EPA). 2020. Ground Level Ozone. Available at: <https://www.epa.gov/ozone-pollution> (accessed 13 March 2020).
- R Core Team. 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <http://www.R-project.org/>.

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