



Air Quality Monitoring 2015 Annual Report

Sequoia and Kings Canyon National Parks

Natural Resource Data Report NPS/SEKI/NRR—2016/1177



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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Erik W. Meyer

National Park Service
Sequoia and Kings Canyon National Parks
47050 Generals Highway
Three Rivers, CA 93271

Annie Esperanza

National Park Service
Sequoia and Kings Canyon National Parks
47050 Generals Highway
Three Rivers, CA 93271

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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 75 parts per billion (ppb) averaged over an 8 hour (h) period. Ozone is a secondary pollutant, formed when nitrogen dioxide (NO_x) and volatile organic compounds (VOCs) combine with warming temperatures and sunlight. Above 75 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 2015). 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, and produce and store food.

From early June to late October 2015, 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 (Figure 1). Daily ozone 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 2015b). 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 2015).

For all of 2015, the Ash Mountain site measured 53 days exceeding federal health standards (Figure 1). This was the most of any NPS unit, and was followed by the Lower Kaweah station in SEKI (23 days) and the Black Rock station in Joshua Tree N.P. (23 days). Most other NPS O₃ stations measured 1 to 8 days or less exceeding federal health standards (NPS 2015a). Although air quality remained poor in SEKI compared to other NPS sites, Ash Mountain and Lower Kaweah recorded the first and third fewest federal health exceedances since 2000, respectively, and didn't reach Unhealthy AQI levels the entire summer (Figure 2). During the advisory season (June through October) in Ash Mountain, August had the highest number of days at the Unhealthy for Sensitive Groups level (Figure 3, Figure 4), as well as the most hours exceeding health standards (Figure 5). During this period, 297 hours (h) over 48 days exceeded 75 ppb, which was down compared to a similar time frame in 2014 (321 h over 53 days). At Lower Kaweah during the advisory season, June had the highest number of days at the Unhealthy for Sensitive Groups level (Figure 6, Figure 7), as well as the most hours exceeding health standards (Figure 8). For the monitoring season, 132 h over 21 days exceeded 75 ppb, which was down compared to the same time frame in 2014 (184 h over 31 days) and 2013 (226 h over 37 days). For a more extensive look at air quality conditions in 2015, including particulate matter pollution, please refer to figures 9 through 16 at the end of this report.

Table 1. Air quality index developed by the EPA to protect public health. AQI breakpoints are from the 2008 standards that are currently being applied to SEKI air quality forecasts. AQI signs in SEKI may still have the breakpoints from before 2008 which represent more lenient AQI categories. Additionally, the standard was recently changed to more stringent breakpoints on Oct. 1, 2015. For SEKI and the region, this could result in several more days in AQI levels greater than “Unhealthy for Sensitive”.

Air Quality Index (ppb)	Health Concern
Good (0-59)	None
Moderate (60-75)	Unusually sensitive people should consider reducing prolonged or heavy exertion
Unhealthy for Sensitive Groups (76-95)	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.
Unhealthy (96-115)	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 (116+)	People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.

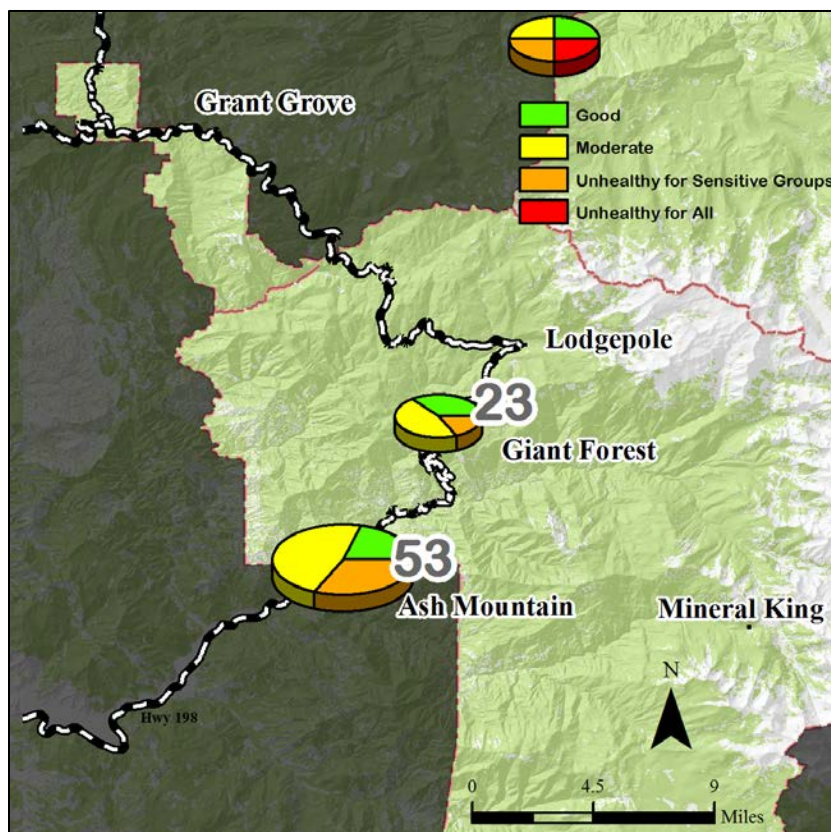


Figure 1. Location of monitoring sites depicting 2015 AQI level results (pie chart) during the ozone season only (June-Oct.), and total number of exceedance days (dark grey) for all of 2015.

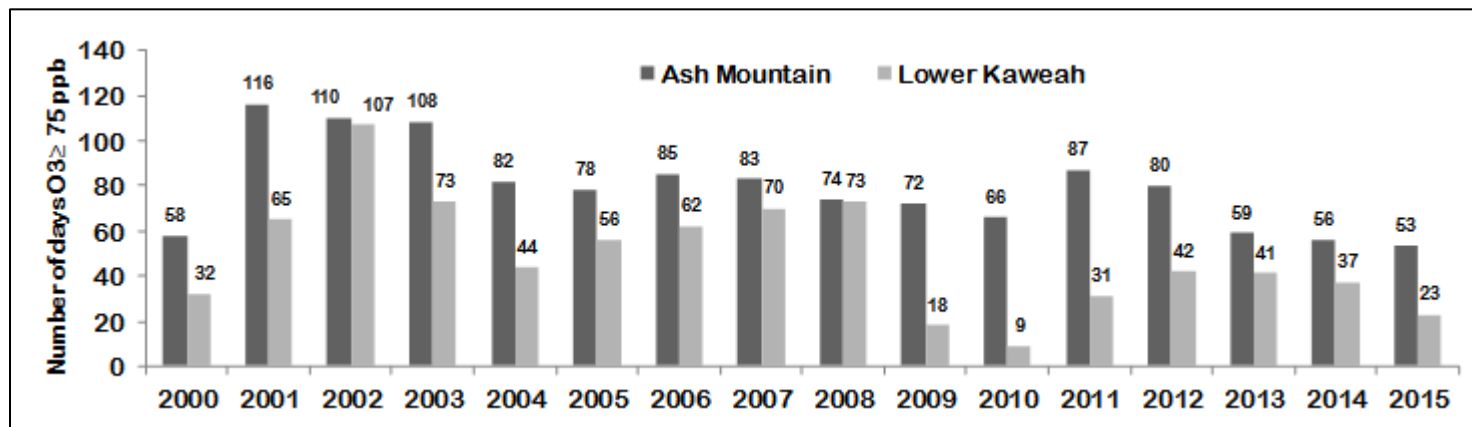


Figure 2. Total number of O₃ exceedances recorded in SEKI since 2000.

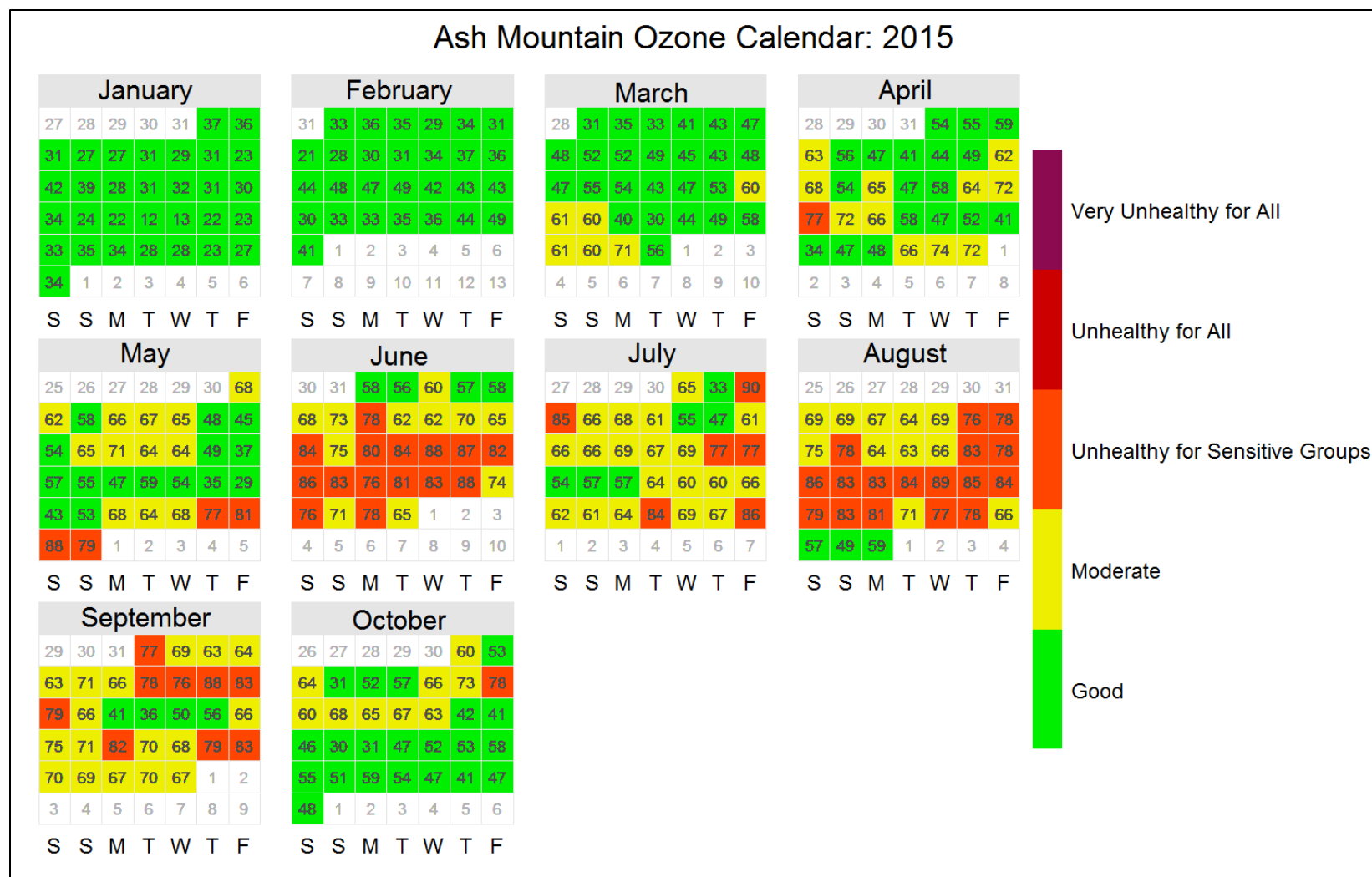


Figure 3. Calendar plot for O₃ concentrations at Ash Mountain. Each day of the month depicts the maximum O₃ 8-hr concentration and the corresponding AQI health level.

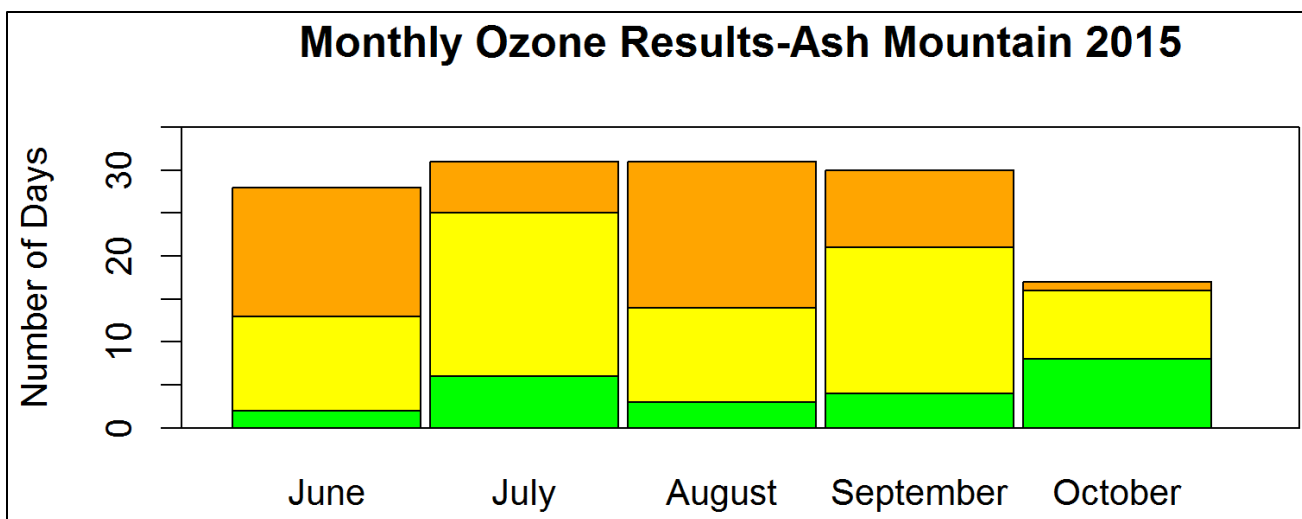


Figure 4 . Number of days each month spent within an AQI level at Ash Mountain during peak O₃ season. O₃ concentrations within the “Moderate” AQI level were the most common, followed by days within “Good”.

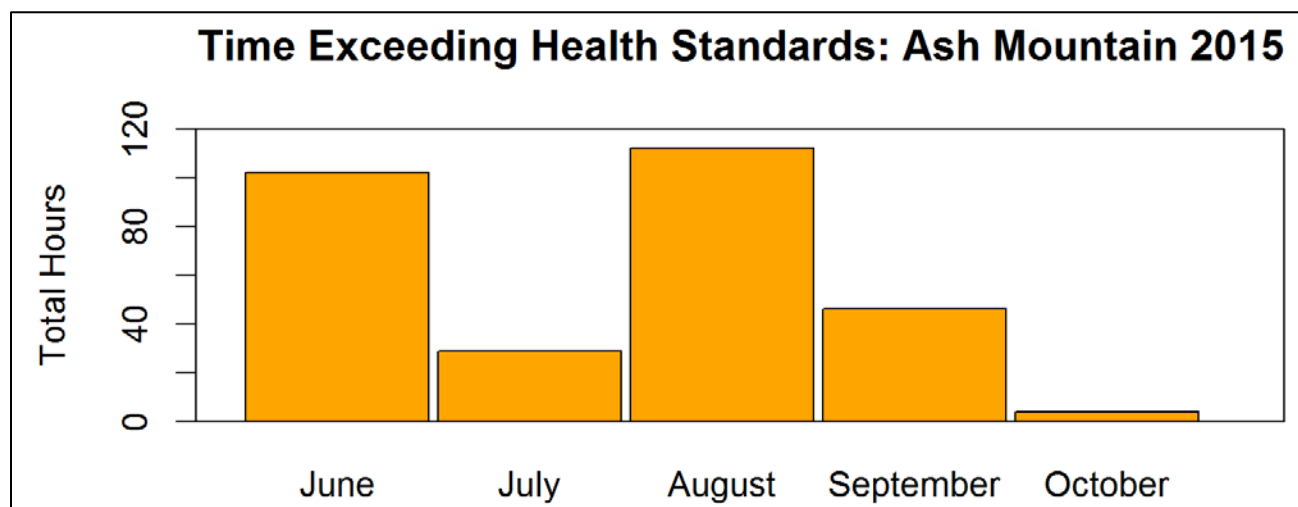


Figure 5. Total number of hours O₃ exceeded 75 ppb in each month at the Ash Mountain air quality monitoring station. Excluded are days where the O₃ monitors were disabled for maintenance.

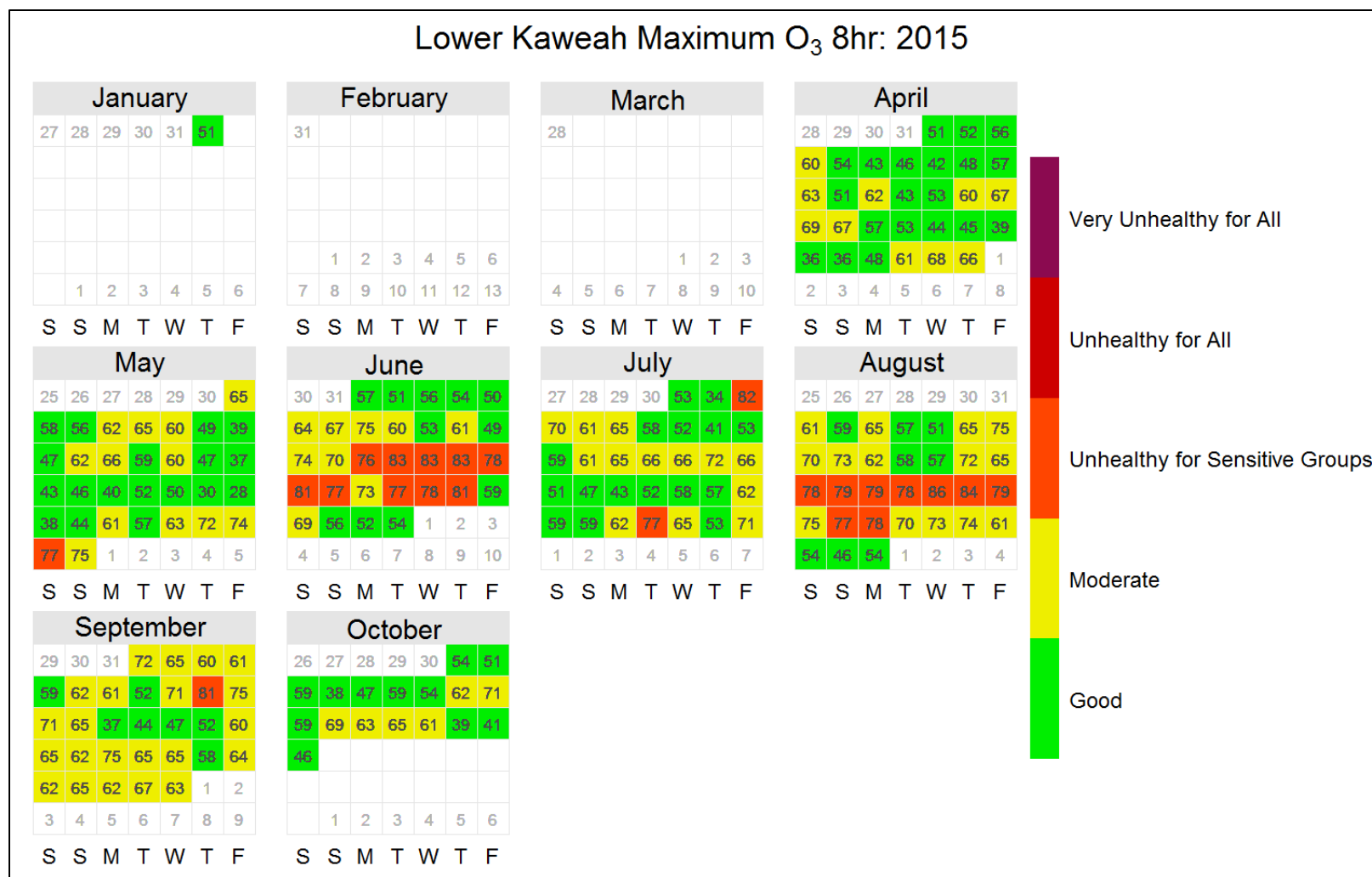


Figure 6. Calendar plot for O₃ concentrations at Lower Kaweah. Each day of the month depicts the maximum O₃ 8-hr concentration and the corresponding AQI health level. Blank days and months represent periods where validated Lower Kaweah data was unavailable.

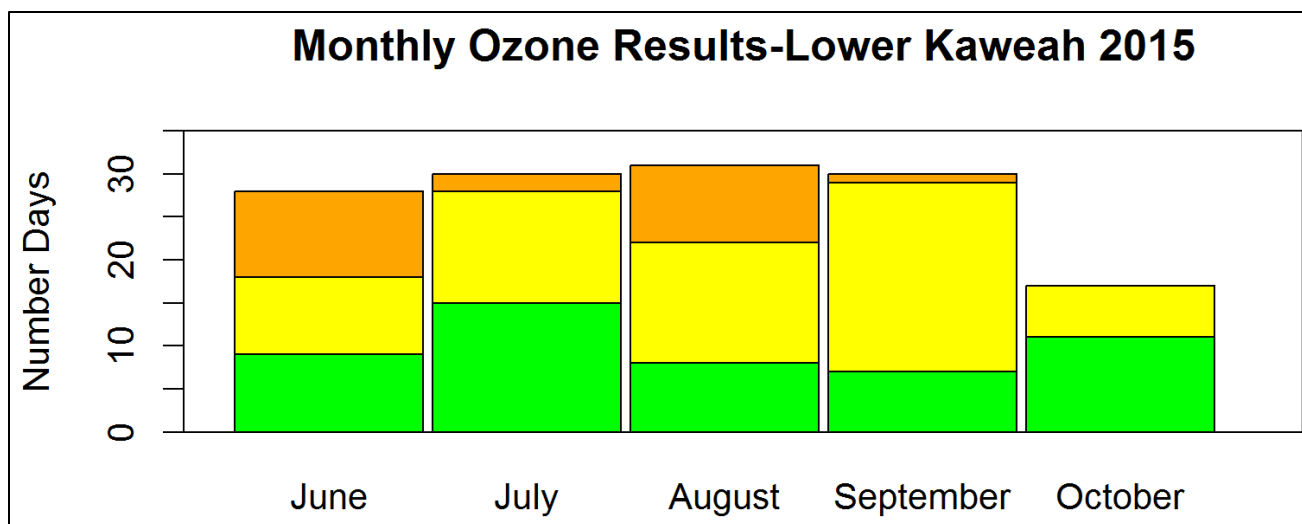


Figure 7. Number of days each month spent within an AQI level at Lower Kaweah during peak ozone season. O₃ concentrations within the “Moderate” AQI level were the most common, followed by days within “Good”.

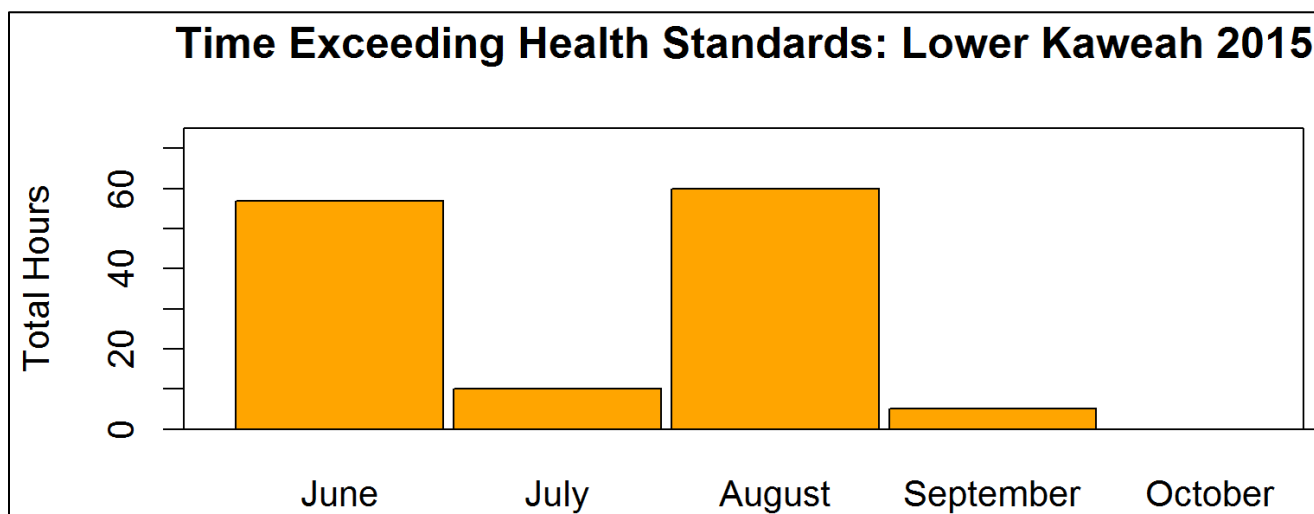


Figure 8. Total number of hours O₃ exceeded 75 ppb in each month at the Lower Kaweah air quality monitoring station. Excluded are days where the O₃ monitors were disabled for maintenance.

SEKI Air Advisory Program QA/QC

Each year, the effectiveness and accuracy of SEKI forecasts are evaluated. In 2015, we began forecasting from our new website. The short url (<http://go.nps.gov/sekiair>) resulted in 1,400 unique visits. There were certainly more unique website visitors when considering visitation at the long url. This year marked the first time SEKI forecasts were made public, and based on website visitation, we consider this transition very successful.

To evaluate the accuracy of SEKI's daily AQI forecasts, we compared our predicted calls with the actual conditions (Table 2). We also compared our forecasts against the San Joaquin Valley Air Pollution Control District (SJVAPCD), who specifically forecasted for all of Sequoia National Park using just the Ash Mountain O₃ station.

In 2015, SEKI was correct roughly 2/3 of the time when forecasting the foothills (via Ash Mountain data) and the middle elevations (via Lower Kaweah data) of the parks. This was a higher percentage than if the public used the SJVAPCD forecasts. Most notably, SEKI performed much better than the SJVAPCD when Air Quality was Good. SEKI forecasted with similar accuracy across all AQI levels, but could improve predicting Good conditions for the middle elevations. SJVAPCD consistently forecasted worse conditions than are actually measured, and routinely forecasted higher AQI levels for the parks than actually existed. Because SJVAPCD forecasted higher than the actual conditions, their ability to correctly call higher AQI levels such as Unhealthy for Sensitive was improved.

Table 2. Forecast accuracy for SEKI and San Joaquin Valley Air Pollution Control District (SJVAPCD). 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.

Forecaster	Actual AQI Condition	<u>Ash Mountain</u>			<u>Lower Kaweah</u>		
		Correct	Forecasted Higher	Forecasted Lower	Correct	Forecasted Higher	Forecasted Lower
SEKI	Across all AQI levels	64%	18%	18%	63%	22%	15%
	When Unhealthy for Sensitive	63%	0%	37%	73%	0%	27%
	When Moderate	65%	24%	11%	68%	9%	23%
	When Good	63%	37%	0%	53%	47%	0%
SJVAPCD	Across all AQI levels	55%	22%	23%	54%	42%	4%
	When Unhealthy for Sensitive	54%	0%	46%	88%	0%	12%
	When Moderate	67%	24%	10%	70%	26%	4%
	When Good	25%	75%	0%	17%	83%	0%

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)	NADP (National Atmospheric Deposition Program)
	-	CASTNET (Clean Air Status and Trends Network)	CASTNET (Clean Air Status and Trends Network)
Parameters Measured	fine and coarse particle (PM _{2.5} & PM ₁₀) mass, elements, sulfate, nitrate, organic and elemental carbon	ozone, wind speed, wind direction, ambient temperature, relative humidity, solar radiation, wetness	Wet: pH, sulfate, nitrate, ammonium, major anions and cations, and mercury in precipitation
	scenic views, scattering, and absorption	-	Dry: sulfur dioxide, sulfate, nitric acid, nitrate, and ammonia;
	-	-	wind speed, wind direction, ambient temperature, relative humidity, solar radiation, wetness
Frequency of Measurements	24-hrs every 3 days	continuous, hourly averages	weekly
			Wet Deposition Data
Access to Data	Visibility Data	Ozone & Met Data	Dry Deposition Data

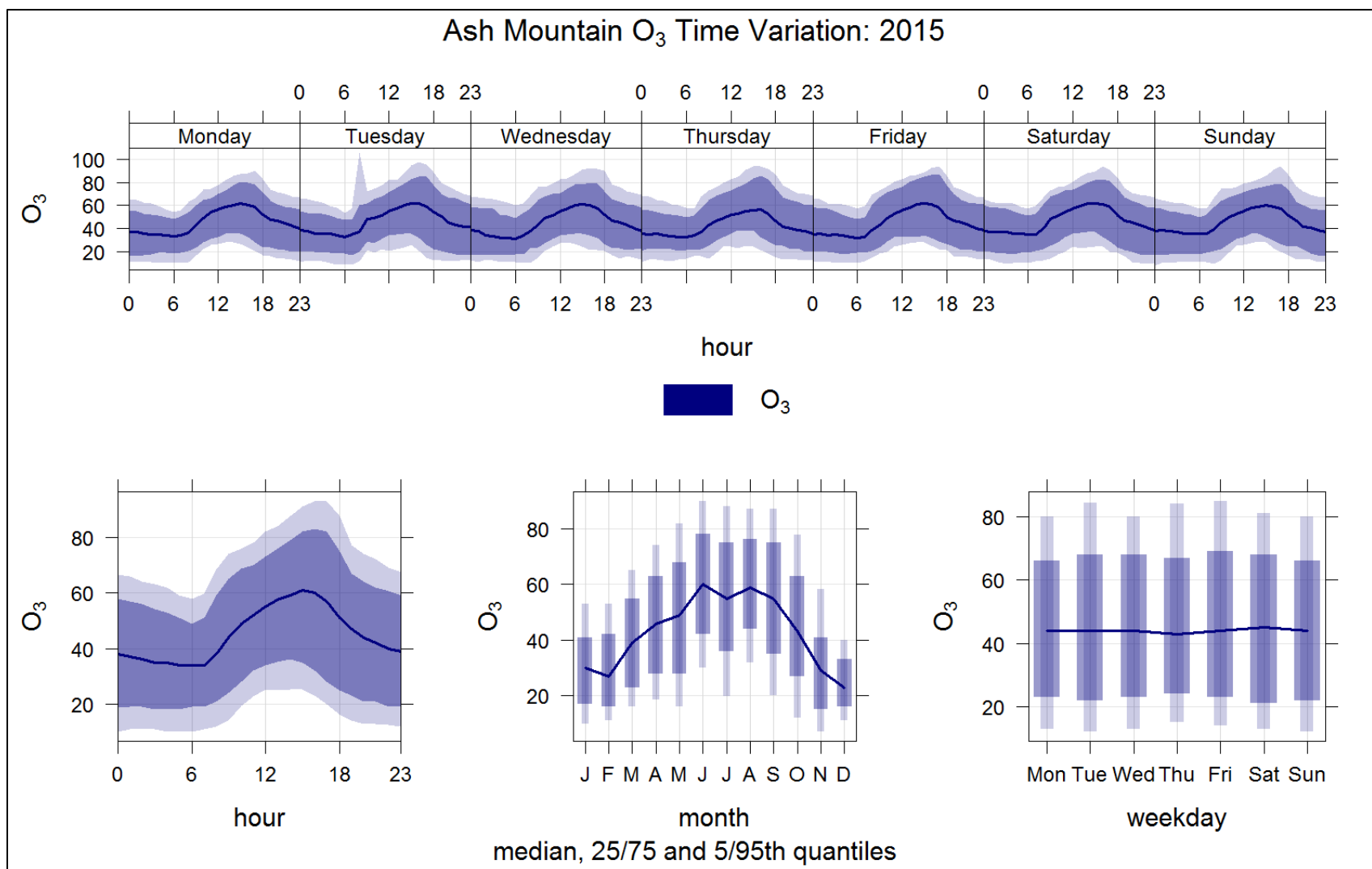


Figure 9. Time variation plot of median hourly O₃ concentrations at Ash Mountain. The purpose of a time variation plot of a pollutant can reveal prominent time of day, day of week, and monthly trends. In 2015 at Ash Mountain, median O₃ concentrations were the highest in the afternoons. The best months for O₃ were from November through April, and the highest concentrations were from May through October.

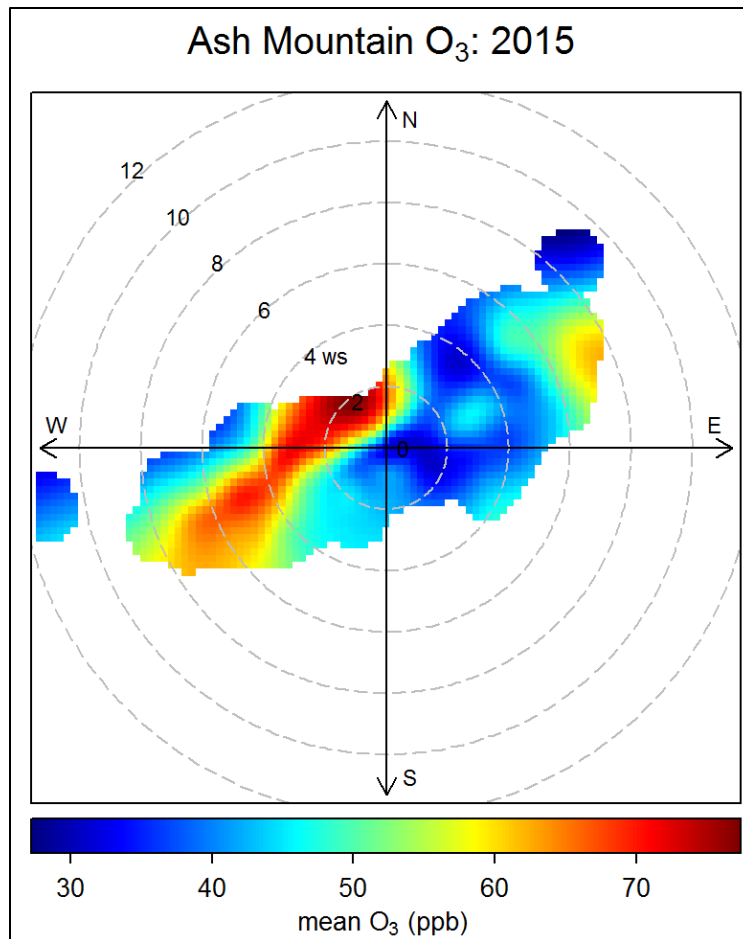


Figure 10. Polar plot of mean hourly O₃ concentrations at Ash Mountain. The polar plot function depicts how O₃ concentration varies by wind direction and wind speed. In 2015 at Ash Mountain, O₃ was higher at low wind speeds (< 2 m/s) coming from the north-west. O₃ decreased at higher wind speeds coming from the north-east.

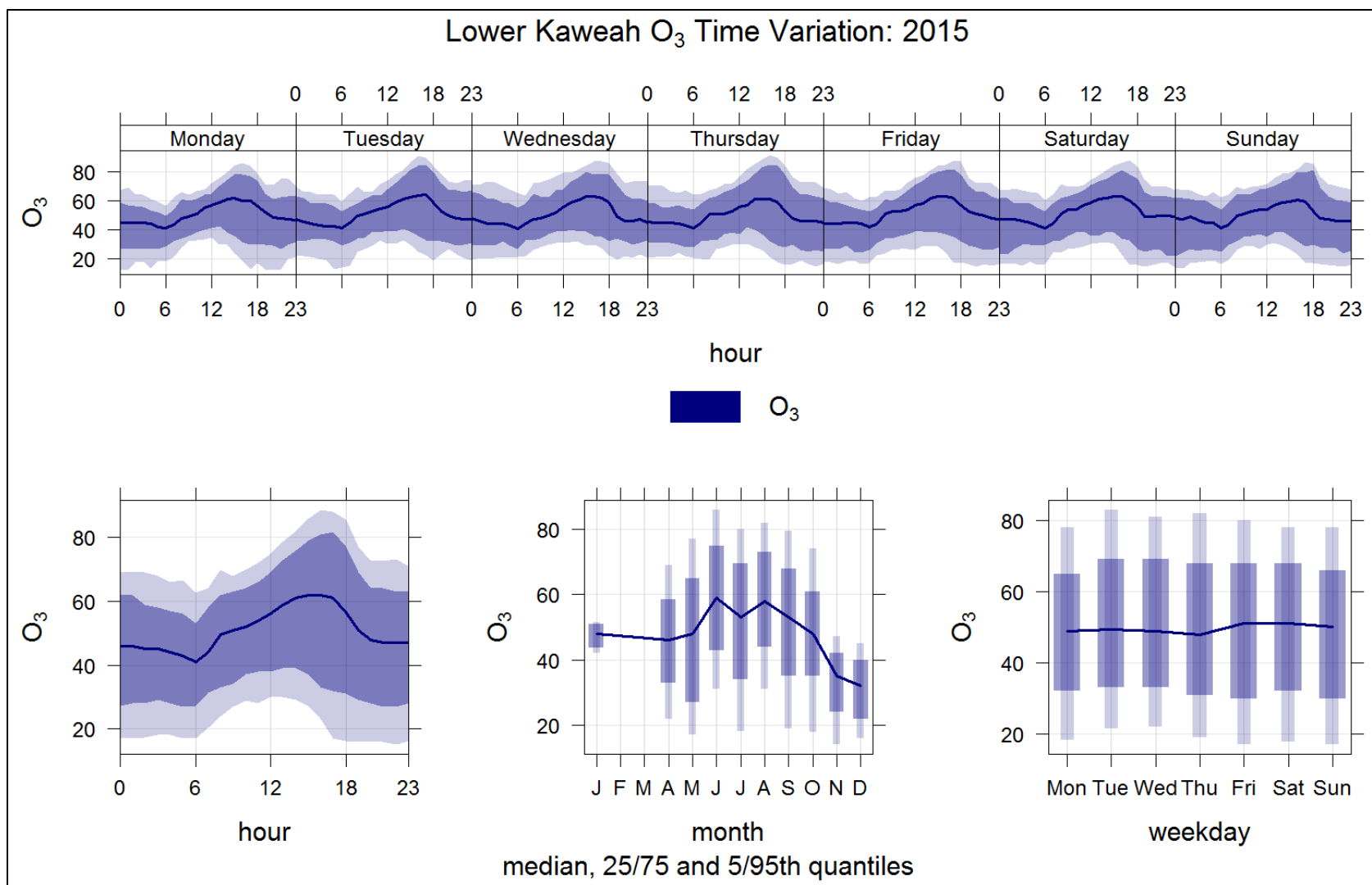


Figure 11. Time variation plot of median hourly O₃ concentrations at Lower Kaweah. The purpose of a time variation plot of a pollutant can reveal prominent time of day, day of week, and monthly trends. In 2015 at Lower Kaweah, median O₃ concentrations were the highest in the afternoon and early evening, 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 (April-November).

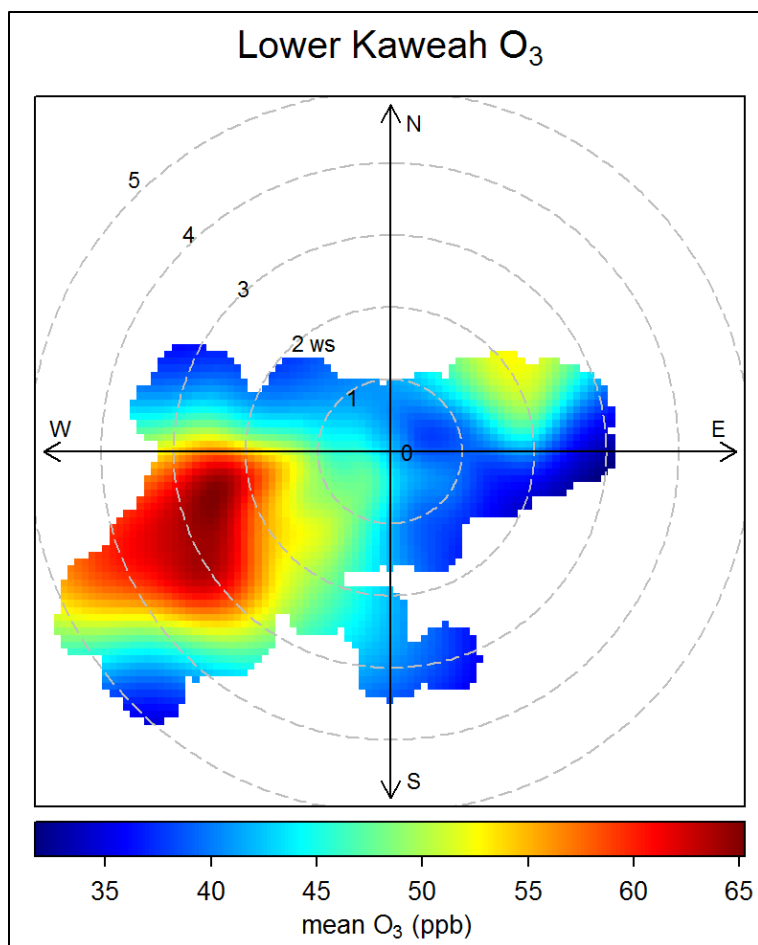


Figure 12. Polar plot of mean hourly O₃ concentrations at Lower Kaweah. The polar plot function depicts how O₃ concentrations vary by wind direction and wind speed. In 2015 at Lower Kaweah, O₃ increased at higher wind speeds (2-4 m/s) coming from the south-west. O₃ was decreased at lower wind speeds (0-3 m/s) coming from the east.

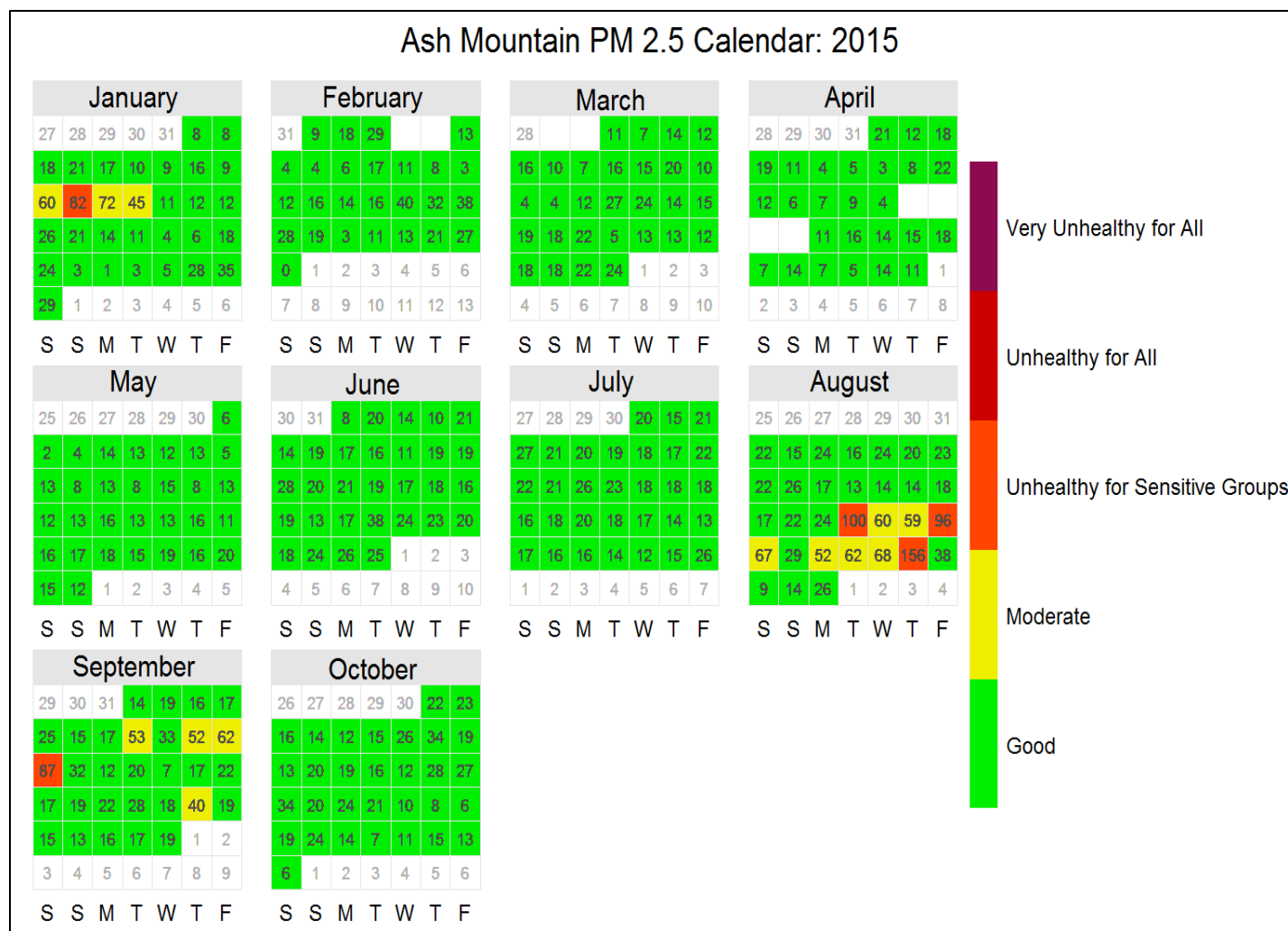


Figure 13. Calendar plot for particulate matter 2.5 microns and smaller (PM_{2.5}) at Ash Mountain. Each day of the month depicts the maximum PM_{2.5} 1-hr concentration and the corresponding 1-hr AQI health level. PM_{2.5} is a criteria air pollutant, and measured year around at the Ash Mountain air quality station. PM_{2.5} originates from natural and anthropogenic sources, at high concentrations is a threat to public health, and also impacts visibility (<http://www.epa.gov/pmdesignations/basicinfo.htm>). PM_{2.5} measured at the Ash Mountain station was consistently measured below health standards in 2015. However, it's important to note that other areas within SEKI periodically measured higher concentrations using mobile monitors, including those deployed during significant smoke events.

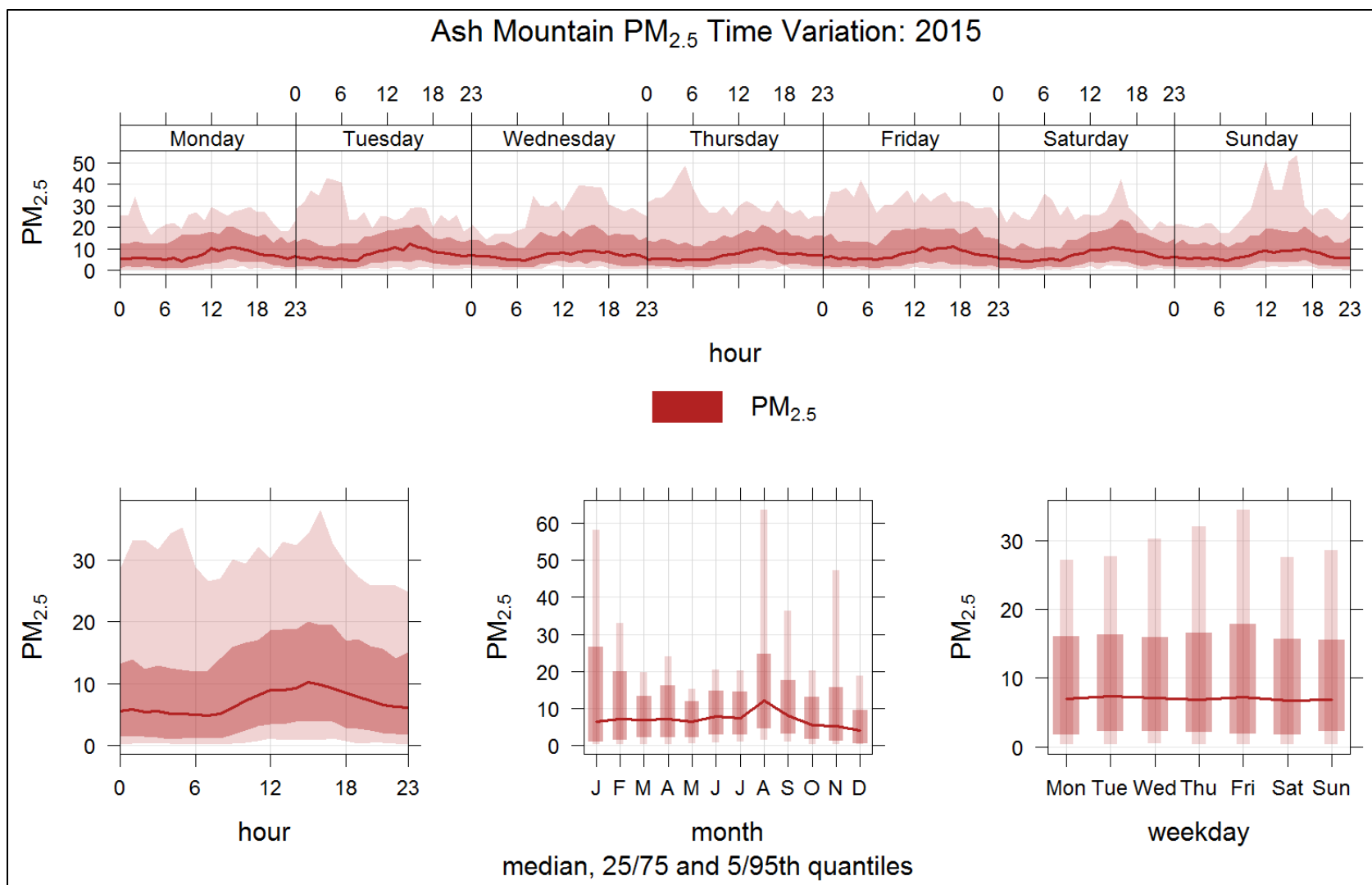


Figure 14. Time variation plot of median hourly PM_{2.5} concentrations at Ash Mountain. The purpose of a time variation plot of a pollutant can reveal prominent time of day, day of week, and monthly trends. In 2015 at Ash Mountain, median PM_{2.5} concentrations were highest in the afternoons throughout the year. The best months for PM_{2.5} were in the spring and early summer months, and the highest concentrations were in January and August.

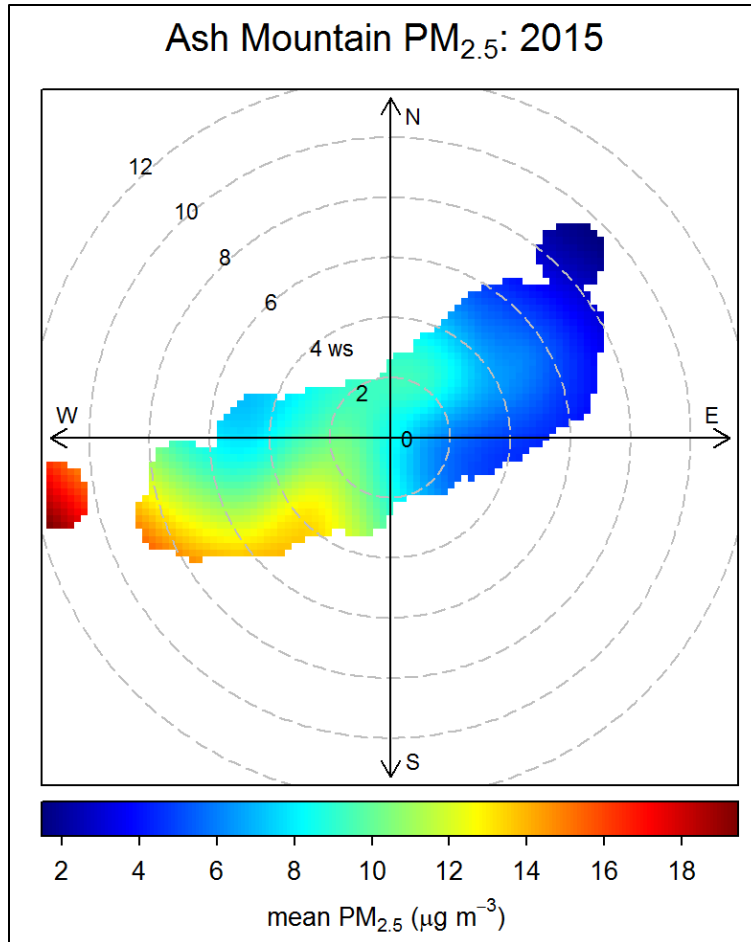


Figure 15. Polar plot of mean hourly PM_{2.5} concentrations at Ash Mountain. The polar plot function depicts how PM_{2.5} concentrations vary by wind direction and wind speed. In 2015 at Ash Mountain, PM_{2.5} was highest when wind was 10-12 m/s coming from the west and south-west. PM_{2.5} decreased at high north-easterly winds.

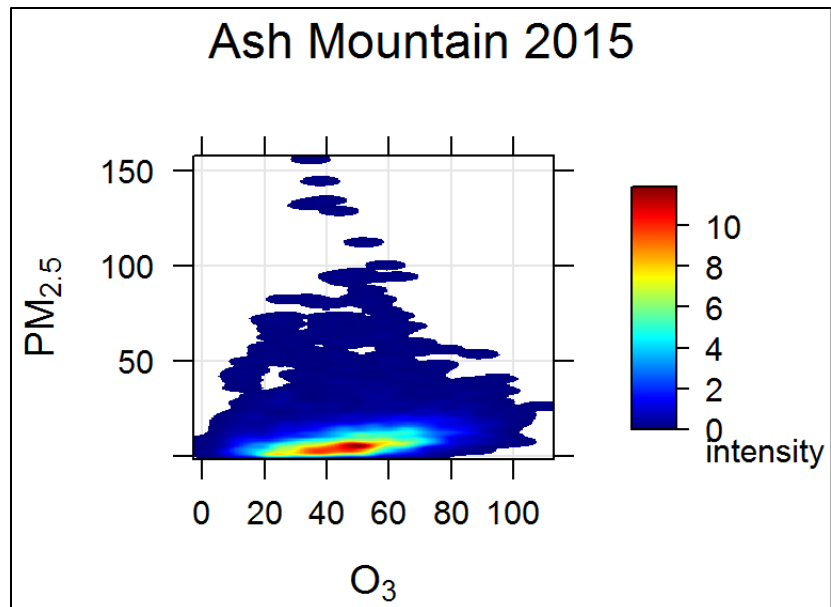


Figure 16. Scatter plot of hourly PM_{2.5} vs. O₃ at Ash Mountain using a kernel density estimate to show where most of the points lie. The darker red intensity indicates the most common relationship between the two pollutants. In 2015, PM_{2.5} and O₃ were commonly found together at low concentrations, 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.

Acknowledgements

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