FINAL REPORT

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Ambient Ozone Patterns and Ozone Injury Risk to Ponderosa and Jeffrey pines in the Sierra Nevada

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Abstract

Spatially explicit estimates of ambient ozone exposure to the Sierra Nevada were developed using data from an extensive survey of passive ozone monitors. The study area included the Sierra Nevada subregion, and extended from the Sequoia National Forest in the south through the Lassen National Forest in the north. Both Westside and Eastside forests were included in the ambient ozone survey. This survey provided data at a total of 94 locations across the Sierra Nevada, of which nine were collocated with active ozone monitors. In addition digital elevation maps, and spatial maps of temperatures and precipitation were developed as part of the analysis.

The unique data set generated from the passive monitor network elicited widespread interest. As a result three analysts were given the data set to develop relationships and estimate spatial patterns of ambient ozone for the Sierra Nevada. Spatial models of biweekly and seasonal ozone distribution were constructed by each group using topographical, weather and other information.

Modeling efforts resulted in a spatial model with an estimated of $R^2 = 0.58$ and with an average standard deviation of 6.68 ppb-hour. Further improvements in the accuracy of predictions are possible because residual analysis indicates unexplained spatial patterns in the data.

The results of these studies also suggest that almost 94% of the study area was reliably estimated for the Sierra Nevada, although the distribution of the measurement sites could still be improved (there was clearly insufficient number of sites on the eastern side of the mountain range). The availability of the weather data and presence of strong correlations between maximum temperatures and elevation with ozone contributed to low sampling site densities being needed to obtain reliable spatial surface estimates in the Sierra Nevada.

Along with monitoring ambient ozone, evaluations of crown injury were performed at 25 sites. Eight Project FOREST sites and 15 other sites located near selected passive monitor sites were evaluated using the Forest Pest Management (FPM) method. All sites were located along the western side of the Sierra Nevada in Jeffrey, ponderosa or mixed conifer forest types.

The number of sites sampled for this study was low, and the distribution of the sample sites did not represent the distribution of the pines. In spite of these deficiencies, patterns of ozone injury generally followed patterns of ozone exposure risk. Although the design of the FPM survey portion precluded a detailed spatial comparison with the ambient ozone samplers, it was of great value for development of future long-term ozone injury monitoring system for the Sierra Nevada.

Introduction

In 1990-1991 a regional program was initiated, the Sierra Cooperative Ozone Impact Assessment Study (SCOIAS), to monitor ambient ozone (O_3) and meteorological variables at six Sierra Nevada sites (Van Ooy and Carroll 1995). Yosemite, Sequoia-Kings Canyon and Lassen Volcanic National Parks, joined SCOIAS by contributing ambient ozone data at three locations within each Park, and the U.S. Forest Service, Pacific Southwest Research Station, provided four years (1992-1995) of ambient ozone data from a site in the San Bernardino Mountains. Van Ooy and Carroll (1995) examined patterns at six SCOIAS sites along the western Sierra Nevada, and observed that some sites had strong diurnal patterns, and some sites had little diurnal variation. In general they concluded that diurnal patterns varied considerably between sites, related primarily to distance from sources, elevation and airflow patterns.

Recent developments in ozone sampler technology have resulted in low-cost samplers useful for large regional surveys (Koutrakis and others 1993). The most widely used passive ozone sampler (Ogawa & Company, USA, Inc., Pompano Beach, FL) was designed for ambient (Koutrakis and others 1993) and indoor (Liu and others 1994) monitoring. The principal component of the coating on the filter medium is the nitrite anion, which in the presence of ozone is oxidized to nitrate. After sample collection, the filters are extracted with ultrapure water, and analyzed by ion chromatography. It has been shown that fluctuations in relative humidity (from 10-80 percent) and temperature (from 0-40 ^{o}C) do not influence sampler performance at typical ambient levels of ozone (40-100 ppb-hr) (Koutrakis and others 1993).

In 1993, measurements made with Ogawa passive ozone samplers were compared with those from UV-photometric ozone analyzers at five sites in two National Parks, by the National Park Service (Ray and Flores, 1994). Passive sampler measurements agreed well for each site and were within ±10 percent accuracy for each measurement period. Excellent agreement between an active ozone monitor (Dasibi Model 1003) and Ogawa passive ozone samplers has also been reported for sites in Mount Rainier National Park (R^2 = 0.997, Brace and Peterson 1994). In Europe, Ogawa samplers have been used successfully in the Krakow Region in southern Poland (Godzik, 1997), in the Carpathian Mountains and Kiev Region in the Ukraine (Blum et al., 1997), and at Praha Peak in the Czech Republic ($R^2 = 0.911$, Bytnerowicz and others 1995). Currently, Ogawa samplers are being used to measure ozone levels throughout the entire range of the Carpathian Mountains in Central Europe (Bytnerowicz, unpublished).

Reports of ozone injury to ponderosa and Jeffrey pines in the 1970s (Miller and Millecan 1971), and subsequent surveys using 10-tree trend plots (Pronos and Vogler 1981), are among the earliest accounts describing the extent and severity of ozone injury in the Sierra Nevada. For example, Pronos and Vogler (1981) reported that between 1977-1980, the general trend was an increase in the amount of ozone injury present on pine foliage in the southern Sierra Nevada.

Peterson and others (1991) sampled crown condition and derived basal area growth trends from cores collected from ponderosa pines in seven federal administrative units in the Sierra Nevada. From north to south, samples were collected in the Tahoe National Forest, Eldorado National Forest, Stanislaus National Forest, Yosemite National Park, Sierra National Forest, Sequoia-Kings Canyon National Park, and Sequoia National Forest. Overall, the results of this study documented the regional nature of the ozone pollution problem originating primarily from the San Joaquin Valley Air Basin, as well as from the San Francisco Bay Area further to the west.

In 1986, 3,120 ponderosa or Jeffrey pines were examined in a cruise survey conducted in Sequoia National Park and Yosemite National Park (Duriscoe and Stolte 1989). More than one-third of these trees exhibited chlorotic mottle. At Sequoia National Park, symptomatic trees comprised 39 percent of the sample (574 out of 1,470) and at Yosemite National Park they comprised 29 percent (479 out of 1,650). Ponderosa pines were generally more severely injured than Jeffrey pines. The calculated Forest Pest Management (FPM) method scores were 3.09 for ponderosa and 3.62 for Jeffrey pine; in this method, a lower score indicates a higher amount of ozone injury (Pronos and others 1978). These cruise surveys characterized the spatial distribution of injury in Sequoia and Yosemite National Parks, and indicated that trees in drainages nearest the San Joaquin Valley experienced the most ozone injury.

The Lake Tahoe Basin is located at the northern end of the Sierra Nevada sampling transect near the Eldorado National Forest (Peterson and others 1991). The basin has distinct air quality problems resulting from a combination of local and remote pollution sources. This is in contrast to most other Sierra Nevada sites where pollution results only from long-range transport. In 1987, a survey of 24 randomly selected plots in the basin found foliar injury on 105 of 360 trees (29.2 percent, Pedersen 1989). For 17 plots, calculated FPM injury scores placed the affected trees in the slight injury category. Sixteen cruise plots (containing 190 trees) were also established to the east of the basin, in an attempt to extend the range of the in-basin observations. Injury at these plots was lower than within the basin, as only 21.6 percent of trees were injured.

Since 1992, Project FOREST has monitored the condition of pines and ozone air quality at ten locations along a north to south transect in the Sierra Nevada from Lassen Volcanic National Park in the north to Sequoia National Forest in the south. One additional site is located in the San Bernardino Mountains in southern California. Injury amounts in the Sierra Nevada range from almost no crown injury (near zero OII values) in the north to moderate crown injury in the south. At the site in the San Bernardino Mountains, located about midway along a west to east gradient of ozone exposure, the amount of crown injury is moderate.

Tree response has been analyzed in Project FOREST in relation to several ozone exposure indices from the nearest monitoring site (Arbaugh and others 1998). Significant associations were found between OII and 4-year, 24 hr summer SUM0, SUM06, W126 and HRS80 ozone indices. These statistical associations were not adjusted for the influence of variable seasonal ozone flux to foliage, which differs each year depending on soil moisture availability (Temple and Miller 1996).

Project Objectives

The first objective of this project was to produce mapped distributions of seasonal accumulated ozone (SUM0) using spatial analysis over the Sierra Nevada using a combination of passive ozone samplers and active ozone monitoring stations. This area includes all locations from the Lassen National Forest (the northern most area) to the Sequoia National Forest (the southern most area). Western and eastern sides of the Sierra Nevada over 1000 meters in elevation were included in the analysis, as well as the interior of the Sierra Nevada. Information from the active monitoring stations alone was not sufficient to develop a meaningful spatial map of ambient ozone for this region. An extensive network of passive monitors augmented the network of active monitoring stations for one summer to identify the key spatial relationships for locations between active monitoring stations.

Part of this objective was also to examine, compare and develop analytical methods useful for spatial estimation in remote mountain areas. Similar studies (Phillips and Herstrom, 1997) have indicated that geospatial analysis (Kriging), or modern regression techniques such as locally weighted regression may have value for this type of data. As part of this study several analysts independently modeled the data, thereby providing a comparison of different analysis approaches.

The second objective was to develop mapped estimates of ponderosa and Jeffrey pine crown injury based on projected summer season ambient ozone exposure. Using the ambient ozone map developed in the first objective, spatial estimates of ozone exposure risk were developed for the Sierra Nevada from the Lassen National Forest to the Sequoia National Forest. This ambient ozone map was then compared with crown injury estimates from 25 sites to examine the ability of spatial exposure maps to estimate ozone injury for sensitive pines of the Sierra Nevada.

Study Design

Site Selection for Passive Monitors and Forest Pest Management (FPM) Surveys

Sites for passive monitors were selected at three general elevations along the north to south gradient of air pollution on the western side of the Sierra Nevada. It was important for spatial extrapolation that sample sites extend below and above the areas for which ozone exposures are to be estimated. Accordingly, low elevation monitor sites were located mostly in oak-chaparral areas below the mixed conifer zone at 1,000-1,400 m elevation. Upper elevation sites were located above the upper boundary of urban transported ozone. The passive and active ozone monitoring sites ranged in elevation from 223 to 2796 meters above sea level (Figure 1).

Figure 1. *Locations of passive and collocated active monitoring stations used in this analysis scattered throughout the national forests and parks of the Sierra Nevada. There are 3 active/passive monitor sites located along an elevational gradient in Sequoia-Kings National Park.*

All sites were located at least 200 m from frequently used roads, in open areas that had good vertical mixing of air. Nine passive monitor sites were collocated with active monitors that were operated continuously over the summer season. Seventeen additional mid-elevation sites were collocated at or near stands of ponderosa or Jeffrey pines that were used for FPM surveys. Digital elevation data (DEM) was used as a collateral data to enhance the quality of the geostatistical estimation of the primary variable – O_3. The relevant, fine resolution elevation data for many topoquads was downloaded from the United States Geological Survey (USGS) web site http://edcwww.cr.usgs.gov/webglis/, resampled to a coarser resolution and merged into a single map. An effort was made to determine the optimal resolution of the DEM for this study. Depending on the purpose of the analysis, the capacity of a computer disk, and the speed of its processing unit, the resolutions from 30 meters to 1 km were found to be valuable for spatial surface estimation.

Meteorological data from 62 weather stations also provided information critical for this study (National Climatic Data Center, WIMS). The meteorological monitoring stations were located across a wide variety of elevations (52 to 2551 meters). The maximum temperature was utilized as a secondary variable for the analyses. Surfaces were generated using the cokriging by the Environmental Systems Research Institute (ESRI) group, while the Pacific Southwest Research Station (PSW) group used a smoothed scatter plot approach. Sample maps of estimated maximum temperatures differed slightly for the two studies, but both indicated that low elevation areas had higher temperatures, while high elevation interior locations were generally cooler.

Passive Ozone Monitors

A single passive ozone sampler, containing two cellulose filters saturated with nitrite was installed at each site (Ogawa & Co.). The samplers were located at about 1.5-2.5 m above ground level in forest clearings (about 20 m or more from the dense forest). At eight to ten monitoring sites in each collection period, two blank filters were also tested. Blank unexposed filters were kept at room temperature in tightly closed plastic vials. In the field, the filters were changed every two weeks during the summer growing season. After the exposures, the filters were placed in plastic vials, and refrigerated until analyzed. Ozone concentrations were continuously monitored by UV absorption (Thermo Environmental Model 49, Cambridge, MA, or an equivalent instrument), at nine active monitoring stations for comparison with the passive samplers.

In the lab, exposed filters were extracted in plastic vials with 5 mL of double-deionized water (i.e., ultrapure water). The filters were shaken for 15 minutes with a wrist action shaker. The extract from each vial was transferred to a 15 mL centrifuge tube, and centrifuged at 5000 rpm for 15 minutes. A 1 mL sample was removed from the centrifuge tube and transferred to a Dionex sample vial, and mixed with 4 mL of double-deionized water. Nitrate concentrations were determined in the diluted extracts by ion chromatography (Dionex 4000i Ion Chromatograph). Ambient ozone concentrations were calculated using an equation derived from comparisons between the readings generated by the active monitor along the transect and nitrate concentrations in filter extracts from the collocated passive sampler. Concentrations of nitrate increase proportionally with increases in ambient ozone concentration (resulting from the oxidation of nitrite by ozone).

Crown Injury Evaluation

Twenty-five sites, near selected passive ozone samplers, were surveyed using the Forest Pest Management (FPM) method. The FPM method is less costly perform than the OII evaluation used for Project FOREST, and the results of both survey types can be related to each other with a high degree of accuracy at the plot level (Arbaugh and others 1998). The FPM method quantifies ozone injury by noting the youngest whorl of needles that shows chlorotic mottle. The index has a range from 0 to 4 for each tree. If there is injury on current year needles, the FPM score is 0. If there is no injury on the current year needles but injury on the 1-year old needles, the FPM score is 1. If there is no injury on either the current year or 1-year old needles, but there is injury on the 2-year old needles, the FPM score is 2. This evaluation is applied through the 4-year old needles, where if no injury has occurred, the FPM score is 4, and the tree is considered to be uninjured by ozone. Thirty trees per site were used to provide a representative sample in the FPM method. All tree observations were made between August 15 and September 15 when injury development is the most apparent (Table 1).

Table 1. *Site locations and average tree characteristics for 25 FPM evaluated sites along the western side of the Sierra Nevada. FPM scores were calculated from three branches averaged to to plot. Any visible injury caused the whorl to be counted as an injured whorl. Crown position 2 is intermediate, 3 codominant, and 4 indicates open growing trees.*

FOREST	SITE	North to South Order	Crown Position (Median)	Whorl Retention (Median)	DBH (Average, cm)	Live Crown Ratio (Average)	Height (Aveage, ft.)	FPM Score (Average)
Lassen NF	Hat Creek	1	3.0	4.17	13.72	58.83	58.6	3.38
Lassen Volcanic NP	*Manzanita Lake***	2	3.0	4.00	14.78	63.67	59.0	2.86
Lassen NF	Mineral	3	3.0	4.00	10.82	52.83	49.6	2.78
Plumas NF	Bucks Lake	4	2.0	4.33	11.91	70.57	54.3	3.82
Plumas NF	Little Grass Valley Reservoir	5	3.0	3.50	12.18	71.17	60.3	3.43
Tahoe NF	Downieville	6	3.0	3.33	13.38	48.33	103.7	3.13
Tahoe NF	*White Cloud***	7	3.0	3.33	14.48	60.50	73.9	2.61
Tahoe NF	Foresthill Seed Orchard	8	3.0	3.00	18.48	70.83	77.0	2.30
Tahoe/Eldorado NF	Blodgett**	9	3.5	3.00	13.74	69.00	101.0	3.34
Eldorado NF	Sly Park	10	3.0	2.83	19.08	53.33	103.0	2.46
Eldorado NF	Bear/Lumberyard	11	3.0	4.33	22.91	69.50	81.0	3.11
Stanislaus NF	Avery	12	3.0	3.00	17.53	52.67	105.5	2.67
Stanislaus NF	*Five Mile***	13	4.0	3.33	11.27	58.62	81.5	2.58
Stanislaus NF	Reed Creek	14	4.0	3.83	14.52	46.67	95.2	2.87
Yosemite NP	Mather	15	3.0	3.33	13.04	52.83	78.8	2.78
Yosemite NP	*Turtleback Dome***	16	2.0	4.00	20.17	63.67	75.4	2.82
Yosemite NP	Wawona	17	3.0	3.67	21.73	63.00	110.6	2.66
Sierra NF	Poison Meadow	18	3.0	4.67	23.28	57.83	82.4	2.18
Sierra NF	*Shaver***	19	3.0	4.67	19.11	55.17	101.0	3.01
Sierra NF	Teakettle	20	3.0	4.33	20.20	58.00	78.0	3.16
Sequoia NP	Stony Creek	21	2.5	2.83	18.69	58.00	77.5	2.81
Sequoia NP	*Lower Kaweah***	22	3.0	2.67	11.83	48.17	91.2	2.89
Sequoia NF	Mountain Home	23	3.0	3.33	13.83	62.50	70.8	0.62
Sequoia NF	Parker Pass	24	3.0	4.83	17.48	68.83	74.0	2.48
Sequoia NF	Liebel/Piutes	25	3.0	5.33	20.90	65.00	91.3	3.70

*** Collocated Active Monitor*

Data Analyses and Model Development

Interest in the unique data set created through this project led to three different data analysts working with ambient ozone data. Each analyst approached the data set differently, and although some of the analysis approaches were similar, modelers considered slightly different aspects of the dataset. At this time two of the modelers have completed their analyses, and the third, United States Environmental Protection Agency (USEPA), is awaiting agency approval before the report can be released.

This section will report the results of Forest Service Statistician, Haiganoush Preisler's results (PSW), and those of Witold Frączek's (ESRI). Results of E. Henry Lee (EPA) was not available at the time of this report. W. Frączek used an analysis approach that incorporated a spatial analysis program that included kriging, splines and inverse distance weighted smoothing. In contrast, H. Preisler used locally weighted non-parametric regression, and kriging as a residual analysis technique. Each analysis approach will be presented separately, and results of both will be reported in the Results section. Separate analysis results from all three analysts will be presented in more detail in an upcoming Elsevier Book, 'Ozone Air Pollution in the Sierra Nevada', A. Bytnerowicz, M. Arbaugh and R. del Allonso (eds).

Relationship between ambient ozone and nitrate oxidation rates

Passive samplers are based on ozone oxidizing nitrite ions, which are coated onto filters, into nitrate ions. The chemical reaction in the filters is

$$NO_2 + O_3 \xrightarrow{\beta} NO_3 + O_2$$

where β is the rate of the reaction. Consequently, the amount of NO_3 in a filter at a given time is

$$NO_3 = \alpha + \beta \times O_3$$

where α is the combined 'background' amount of nitrate already in the filter and local site effects, and β is as above. In practice α due to nitrate in filters = 0, because blanks are used to determine the starting nitrate in the filter. Estimation of α and β is done using simple linear regression. Original estimates of β were developed by Koutrakis et al. (1993) in controlled laboratory conditions, but estimates were found not to be accurate in field studies and α was assumed = 0. There are several choices to estimate the values of β and α for field applications: 1) Use a common slope and intercept estimated from all collocated sites; 2) Use a separate slope and intercept for each collocated site. At sites with no collocated active monitors use the slope and intercept from the nearest active site; 3) Include covariates (e.g., elevation and maximum temperature) in the estimation of slopes, intercepts to convert passive sampler observations to ambient ozone levels.

In this study a plot of the linear regression lines of observed nitrate levels versus ozone levels from nine collocated sites (Figure 2) indicated that slopes and intercepts were significantly different at the various sites. The Shaver Lake active monitor appeared to be an outlier. Nitrite oxidation rates were over 50% greater than at other sites for similar ambient ozone levels. It is likely that the monitor needs to be calibrated, or that some local effect related to the monitor is causing the unusually low ozone measurements. Observations from the Shaver Lake active monitor were not used in either analysis.

Additional analysis of the relationships between the estimated slopes and intercepts, and explanatory variables (elevation, maximum temperature, precipitation) indicated that the intercept was increasing with maximum temperature and that intercept at elevations higher than 1500m were lower than average. All other relationships between the slopes and intercepts and the covariates were found to be not significant or only marginally significant. These results may indicate that passive samplers have undocumented sensitivity to temperature, and to humidity or atmospheric pressure extremes. Some variability, especially to high temperature, is consistent with the chemical kinetics involved with the passive monitor approach. This sensitivity, and development of adjustment factors for these environmental differences will be developed in a future study at Riverside Forest Fire Research Laboratory.

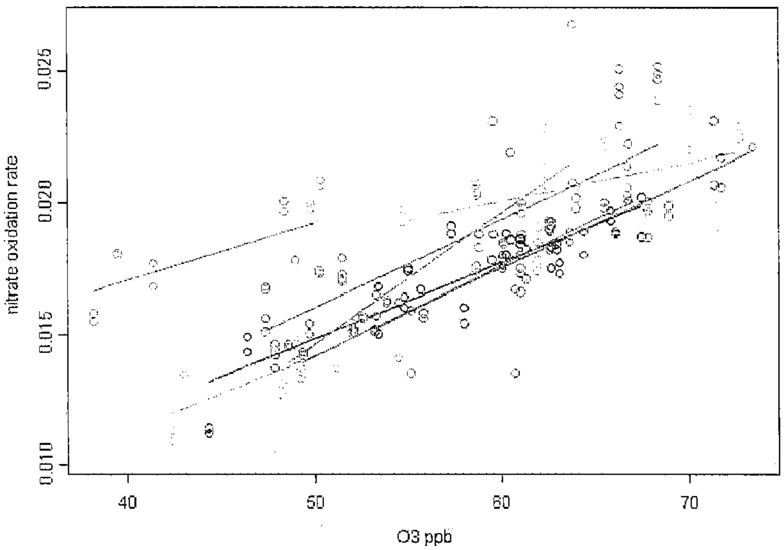

Figure 2. *Relationships between ozone levels observed at active monitors and those observed by passive samplers at the collocated sites. Shaver Lake (red points and line separate from other lines) appears to be an outlier.*

Environmental measurements were not available at passive sampler locations, and few continuous monitoring sites had meteorological instrumentation, thus method (3) was not possible to explore. A preliminary analysis was conducted to compare analysis results using method (1) and (2). Results indicated that using separate values, method (2), did not affect final maps describing estimated spatial ozone patterns. Based on these results both PSW and ESRI used the simpler method (1) for this study.

Geostatistical Analysis (ESRI)

Maps showing spatial distribution of O_3 concentration were created with the Geostatistical Analyst Extension to ArcGIS 8.1 software produced by Environmental Systems Research Institute (ESRI), Redlands, California. The Geostatistical Analyst uses sample points at different locations in a landscape and interpolates the values measured at these sites into a continuous surface. Using this approach, a spatial model of prediction or estimation of O_3 concentrations was derived. The Geostatistical Analyst provides a comprehensive set of tools for data exploration and for creating surfaces that can be used to visualize, analyze, and understand the geographic phenomena of interest.

Testing of Geostatistical Analyst

A preliminary evaluation of Geostatistical Analyst (ESRI Inc.) was performed to decide which modeling methods (e.g. inverse distance weighting [IDW], Spline) or geostatistical methods (kriging, cokriging) along with their geostatistical algorithms (e.g. ordinary kriging, simple kriging, universal kriging, disjunctive kriging) and semivariogram models (e.g., spherical, exponential, Gaussian, J-Bessel) would provide the most accurate estimation of O_3 concentration surface. A total of 28 methods of data interpolation were applied and compared. The selection of a geostatistical interpolation algorithm to generate maps of ozone concentration distribution was based on the statistical characteristics of each output surface using cross-validation measures. Six cross-validation prediction error parameters were taken into account: mean, root-mean-square, root-mean-square standardized, average standard, mean standardized, and a difference between root-mean-square standardized and average standard errors for geostatistical algorithms. Only the first two statistical characteristics could be calculated for the IDW and spline methods. A minimum of 5 of the nearest measurement points were used for calculating predicted ozone values at any given location.

Comparison of various parameters describing the quality of prediction did not provide a clear, unequivocal answer on what method most accurately estimated ozone spatial distribution. Based on the lowest prediction parameters error criteria, the best eight outputs were: spherical and K-Bessel models of cokriging with elevation as supplementary data set; best fitted representatives of spherical, exponential, Gaussian, and circular models of kriging; IDW with 15 neighbors; and spline with tension. Statistical prediction errors were similar for all final eight season average O_3 prediction candidate maps for the 1999 season. The spherical model of cokriging with elevation and maximum temperature as secondary variables were evaluated to be the overall best and was utilized in this study to generate all maps of ozone predictions.

Geostatistical Analyst also identified a strong correlation between temperature and elevation above sea level. Consequently, both the maximum temperature and elevation were included as secondary and tertiary variables for the applied ordinary cokriging model. In order to generate a dependable surface of maximum temperatures that could be used for the model of the O_3 distribution, cokriging was used. The map of estimated maximum temperatures was based on the measurements from the weather stations cokriged with the elevation data (DEM) applied as the secondary variable. This map was very similar to the elevation map because of the strong relationship between elevation and temperature that was taken into account by the cokriging method.

The Geostatistical Analyst included an option to calculate the standard error of predicted of O_3 concentrations. That allowed creating maps of predicted standard error using the same interpolation algorithm that was used to generate the O_3 distribution maps. A threshold distance from monitoring sites at which estimated values linearly depend on the measured values was set to delineate areas of estimated O_3 concentrations with sufficient confidence. The continuous reliability surface of the entire study area was then classified into four categories of potential error of prediction. The zones closest to the areas of the highest density of monitoring sites were considered satisfactory in terms of the density of the sites and consequently, the accuracy of prediction of O_3 concentrations.

Spatial Estimation of Ambient Ozone (PSW)

The PSW group used locally weighted regression models to estimate spatial and temporal patterns of ozone and the relationships between auxiliary (explanatory) variables and ambient ozone. The model used was as follows:

Let Y_{ijk} be the amount of nitrate per hour of the k^{th} sample (replicate), at the i^{th} site, and time t_{ij}. A locally weighted regression model with random effects was used to characterize the relationship between the amounts Y_{ijk} and the explanatory variables. Specifically, we used the model

$$Y_{ijk} = g_0(lon_i, lat_i, t_{ij}) + \sum_l g_l(X_{lij}) + \tau_i + \varepsilon_{ijk} \quad (1)$$

where

X_{lij} = value of the l^{th} explanatory variable (e.g., temperature or elevation),

lon_i, lat_i = longitude and latitude of the i^{th} site, the location of the i^{th} passive sampler,

τ_i = unobserved random site effect assumed to be Gaussian with mean zero and variance σ_τ^2,

ε_{ijk} = unobserved independent random noise with mean zero and variance σ_ε^2,

$g(.)$ = a non-parametric smooth function.

Four explanatory variables (l =1,...,4), average maximum temperature and precipitation, ambient ozone level at nearest active site, and elevation were used in the model. The first three variables were spatially and temporally explicit (i.e., had different values at different locations and times) while the fourth variable (elevation) was spatially explicit. The smooth function of location and time, $g_0(lon_i, lat_i, t_{ij})$, was included in the regression line to account for general spatial patterns not explained by any of the four covariates (e.g., patterns due to wind). A random site effect was included in the model to account for site-specific characteristics due to unknown or unobserved site covariates. The between record error terms, ε, were assumed to be independent. Similarities between observations at different sites were partially accounted for by including a smooth function of location in the equation of expected values. In contrast, other approaches, e.g., kriging, universal kriging, or polynomial trend surface models, assume the error terms to be spatially correlated (Phillips and others, 1997). In the latter approaches an overall polynomial regression is usually used to fit a trend surface to the data and a nonzero covariance matrix is estimated via restricted likelihood function (Cressie, 1993). The present approach uses locally weighted polynomial regression. This has the advantage of overcoming problems associated with the trend surface and kriging estimation technique due to unevenly spaced data, boundary problems, or anisotropy (Venables and Ripley 1997). Locally weighted regression models, such as `loess` or `gam` in SPLUS (S-PLUS 1997), may be used to estimate the smooth functions in the model above. However, the standard versions of these programs do not include allowances for the presence of random effects such as the random site effect assumed in model (1). In order to estimate the random effects component of the model an iterative procedure was used based on the EM-algorithm (Hastie 1992, Dempster and others 1997) and the equations given in Brillinger and Preisler (1985).

Standard error estimation(PSW)

A modification of the grouped jackknife procedure (Efron and Tibshirani 1993) was used to estimate standard errors of the predicted values. The grouped jackknife procedure is based on leaving a subset of observations out at a time then running the estimation procedure on the remaining observations. The standard errors of the predicted estimates are then calculated from the pseudo-values $\hat{\mu}_k = k\hat{\mu}-(k-1)\hat{\mu}_{(k)}$ where $\hat{\mu}$ is an estimate using all the data and $\hat{\mu}_{(k)}$ is an estimate with the k^{th} group removed. A natural grouping of the nitrate data was groups of observations from each site. However, the variability in the pseudo-values obtained by dropping one site at a time was very large. Some of the sites had a large influence on the estimated values with the effect that standard error estimates calculated in this fashion were too large. This was verified with a simulation study where we were able to compare the estimated jackknife standard errors with the true standard errors. As a result the standard error calculations were made using a modified jackknife procedure where the observations from deleted sites were replaced by their expected values estimated from the rest of the data (Brillinger, 1966).

Assessing goodness of fit of model (PSW)

Normal probability plots of the residuals were produced to assess the Gaussian assumption of model (1). Cross-validation techniques were used to produce plots of observed versus expected values, with expected values at a given site calculated using data from all other sites. Another useful set of plots for assessing overall goodness of fit were those of the estimated ozone values compared with the observed ozone values at the collocated sites. Estimated directional variograms of residuals plotted against distance were used to assess the assumption of spatial independence of the error terms. The resulting plots from this study will be discussed in the following sections.

Estimating probability maps for SUM0 (PSW)

Air resource managers are interested in spatial patterns of risk to air quality related values (Air Resource Management, 1998, Campbell and others 2000). Previous studies (Miller and others 1996; Salardino 1996; Arbaugh and others 1998) have shown that foliar injury and cumulative ozone exposure are linearly related. Thus, probability maps of cumulative summer season 24hr ozone levels (SUM0) exceeding critical levels are the starting place to estimate risk of ozone injury to pines.

Using the model described in equation (1), the probability of SUM0 for a given period of time exceeding a critical amount is given by

$$\Pr[SUM0_i > C] = 1 - \Phi\left(\frac{C - \hat{M}_i}{\sqrt{\mathrm{var}(SUM0_i)}}\right)$$

where

C = a critical total amount of ozone over a particular period of N days.

Φ = standard Gaussian distribution function.

$$\hat{M}_i = E(SUM0_i) = 24 \times 14 \sum_{j=1}^{J} \hat{\mu}_{ij}$$

$\hat{\mu}_{ij}$ = estimated amount of hourly ambient ozone level at site i and for the j^{th} 2-week collection period.

$J = N/14$

$\mathrm{var}(SUM0_i)$ = variance of the cumulative ozone level at site i.

An estimate of the variance of *SUM0* for the random effect model used in this study is given by the formula

$$\widehat{\mathrm{var}}(SUM0_i) = (24 \times 14)^2 J[\widehat{\mathrm{var}}(\hat{\mu}_{ij}) + \hat{\sigma}_{\varepsilon}^2 + J\hat{\sigma}_{\tau}^2]$$

The resulting surfaces indicate areas of high and low risk for fixed ozone exposure levels, which can be expressed as seasonal cumulative or daily average ozone concentrations. Comparison of these surfaces with ozone injury scores can also indicate whether the surfaces are useful as estimates of ozone injury risk, as well as for ozone exposure risk.

Results and Discussion

Maps of estimated hourly ambient ozone levels estimated in the ESRI study indicated that ozone levels in 1999 were highest in the western, south-western and south-eastern regions of the Sierra (Figure 3). This result is consistent with previous reports of active monitors and observed foliar injury studies (Miller 1996, Salardino 1996, Arbaugh and others 1998). The estimated spatial surface of ozone concentrations (Figure 3) were detailed for the study area, but reliability of prediction in the northeastern and southeastern parts of the map is questionable due to a lack of measurement sites in these remote areas.

Temporal changes in ambient ozone occurred throughout the study season. Early season mean ambient ozone from continuous monitors ranged from 40-60 ppb-hr (May 15) and increased to a level of approximately 50-70 ppb-hr during mid-summer. In early August ambient ozone dropped abruptly for one 2-week period to spring levels, then gradually increased to previous summer levels. At the end of the season ozone levels were still slightly elevated above spring levels. Spatial patterns estimated by PSW indicated that both spatial distribution and mean amounts of ozone varied over the study season (Figure 4), probably as a result of mesoscale changes in weather. The western Sierra Nevada may experience several types of seasonal wind patterns, which is complicated by changes in eastside and southerly wind patterns, and mountain precipitation due to seasonal convection storms.

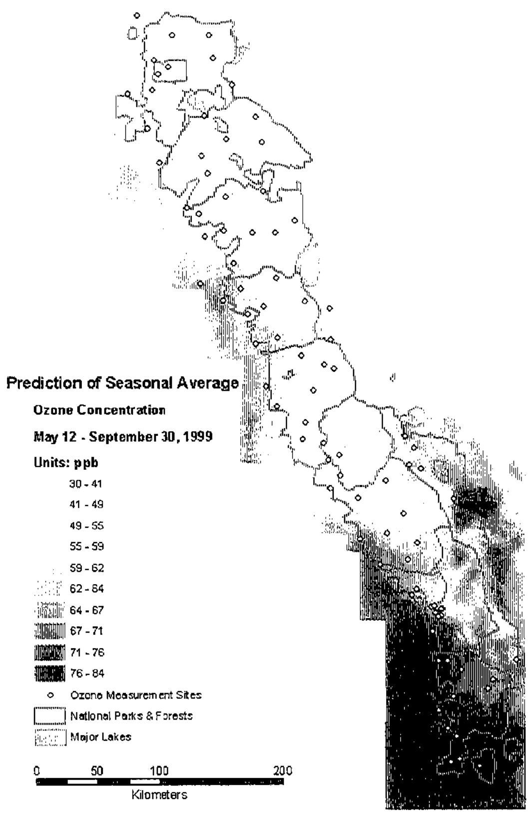

Figure 3. *Prediction of ozone concentration based on cokriging of ozone, maximum temperature and elevation from ESRI study.*

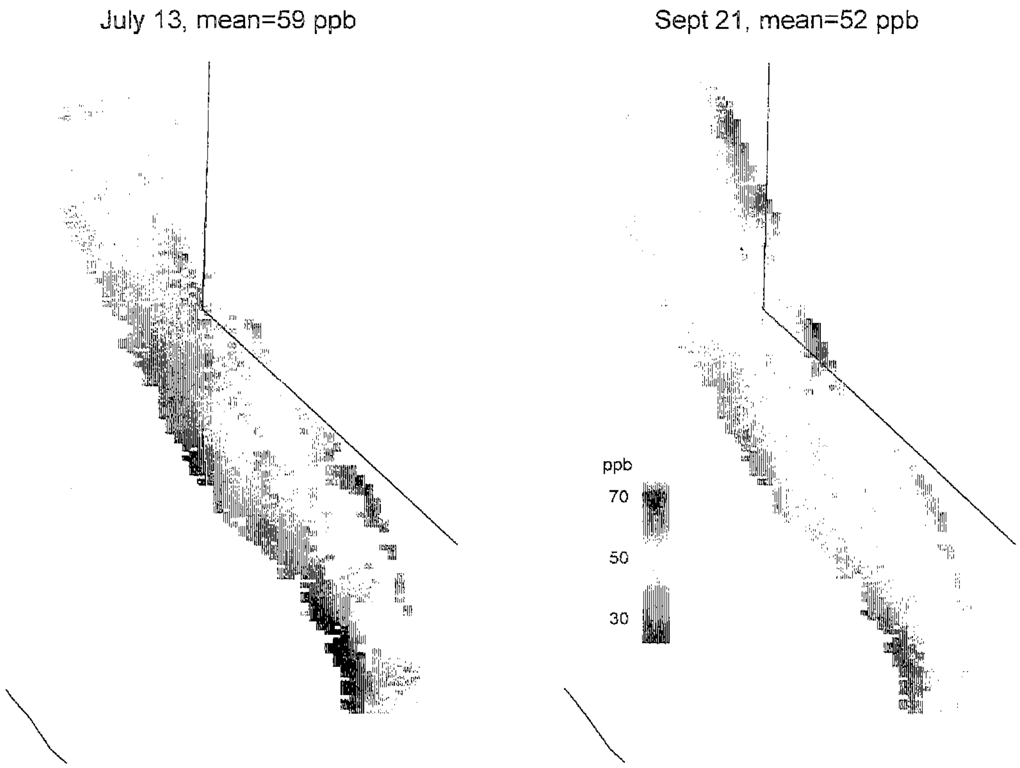

Figure 4. *PSW estimated spatial patterns of ambient ozone for two time periods. Notice that both spatial pattern and mean ambient ozone differ for the two graphs.*

A prediction standard error map was generated in ESRI study to examine the extent that predictions should be made between sample locations (Figure 5). The lightest areas on the map represent the highest confidence of prediction of O_3 concentration. The dark areas represent areas with the low confidence. The estimated standard error of prediction was assumed to vary continuously over the study area, gradually increasing and decreasing rather than abruptly changing over small geographic distances.

The goodness-of-fit of the generalized regression ambient ozone model (PSW) indicated that there were 24 values (outliers) in the normal probability plot (Figure 6) that appeared to be smaller or larger than expected under the assumed model. These values may indicate either the need for more accurate or additional explanatory variables. For example, the maximum temperature values used at each site were the values of the smoothed surface of temperatures estimated using weather station data. Site specific temperatures produced in this fashion are usually not good estimates of extreme values. Even with using estimated temperatures, only 1.4% of the observations seemed to be outliers. The additional expense of locating meteorological stations with each passive monitor may not be justified.

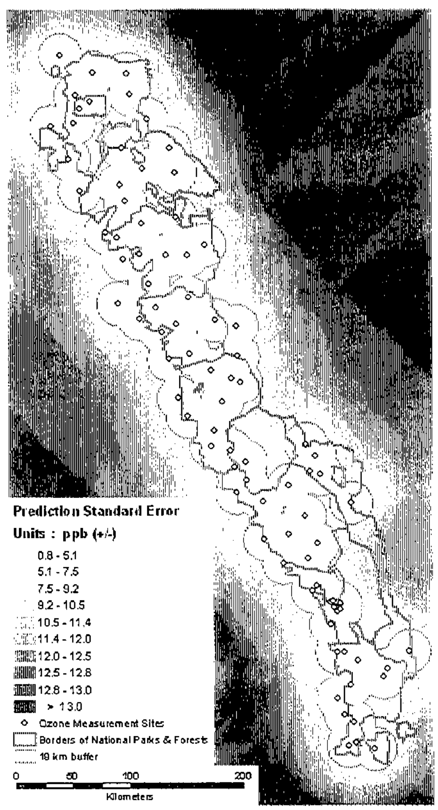

Figure 5. *Predicted standard error of estimation of ozone concentration in Sierra Nevada Mountains for ESRI study.*

Estimates of directional variograms of model residuals from the PSW study indicated that the assumption of spatial independence of the error terms was adequate. The variograms in all direction were basically flat, indicating no autocorrelation. Approximately 94% of the observed values were within the estimated point-wise 95% confidence bounds produced by the cross validation study. Some of the points outside the 95% bands were the extreme values already discussed above. However, a new group of outliers (all from the Woodsford site in Eldorado Forest) were detected. All the observed values at this site were greater than two standard deviations from the expected values.

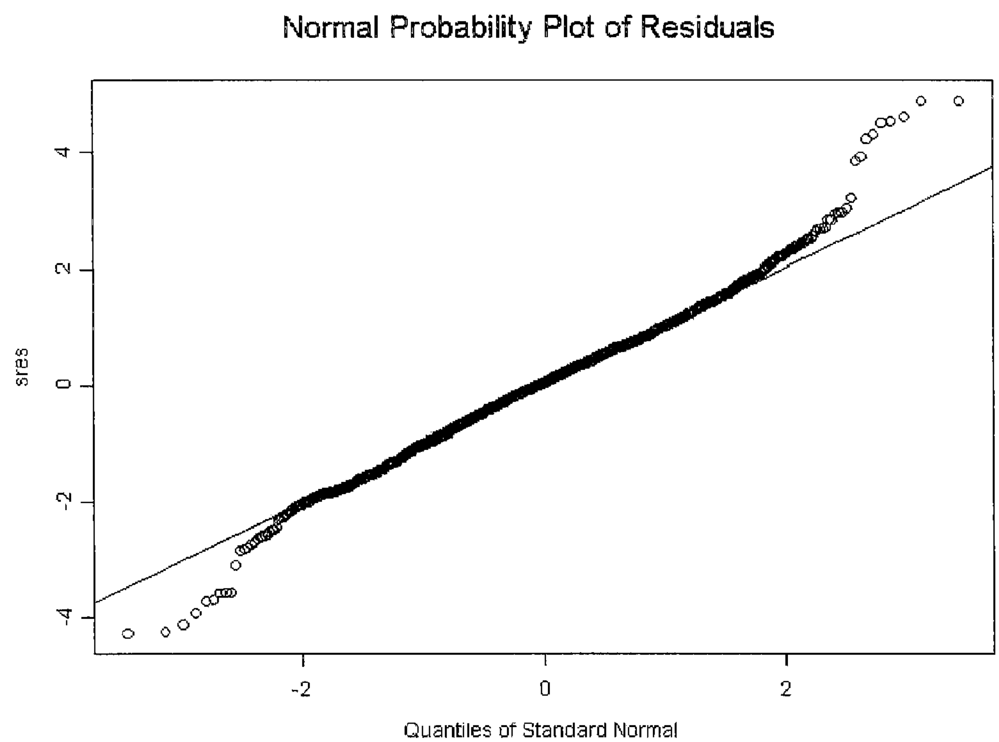

Figure 6. *Normal probability plot of the residuals after fitting model (1) to the bi-weekly nitrate data observed at passive monitors over 5 months. Circles at the bottom and top of the graph indicate model residual outliers.*

Estimated between site variation ($\hat{\sigma}_\tau$ =3.8 ppb-hr) was significant when compared with the record-to-record variation ($\hat{\sigma}_{\varepsilon}$ =5.4 ppb-hr). Approximately 33% of the total variation was due to between site variations in the PSW study. Comparison of observed and fitted values of ambient ozone at 8 of the collocated sites (Figure 7) indicates that at four of the eight active monitor sites model estimates of ambient ozone were biased. This may indicate either that a landscape scale explanatory variable is missing from the analysis, or that there is a micro-site influence affecting some of the passive monitors.

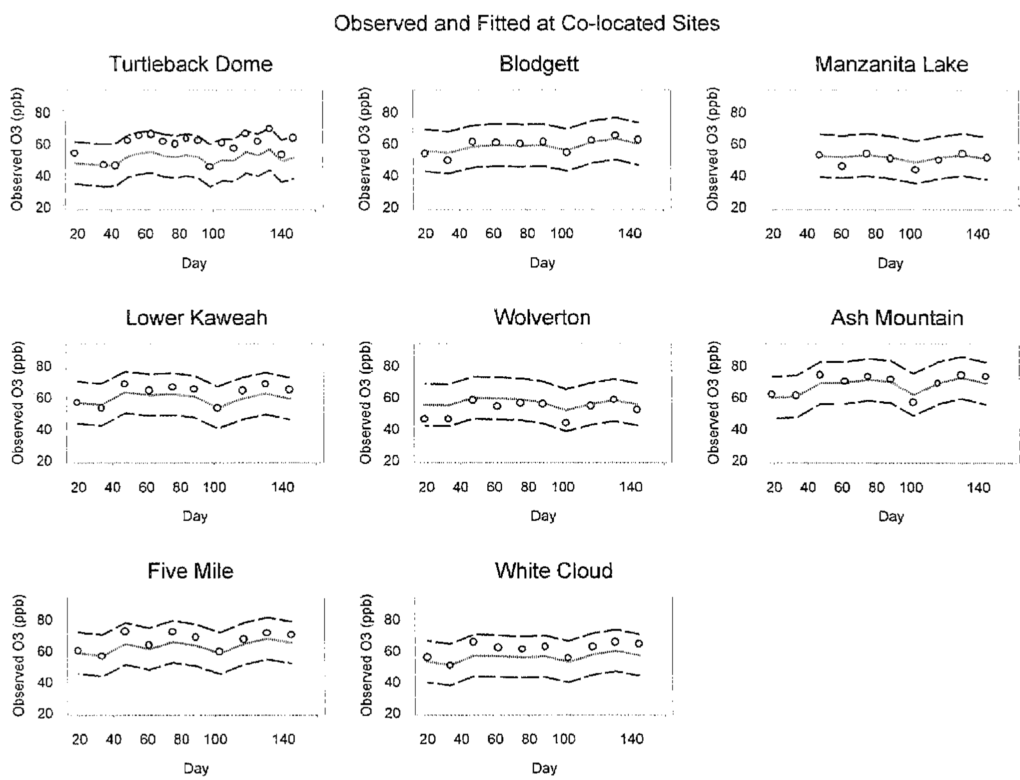

***Figure** 7. Observed versus estimated ozone levels at collocated sites. The red circles are the actual bi-weekly average ozone levels recorded by the active monitor. The blue lines are the expected ozone levels and their corresponding 95% confidence bands. Biased estimates occur when red circles are consistently above or below the blue line.*

The conditional effects of each of the explanatory variables (including spatial location) after removing the effects of the other variables (Figure 8) indicate that although all 6 variables were significant at the 5% level, the variables with the largest effect on ozone levels were maximum temperature and elevation. Explanatory variables were not independent, hence relationships may differ from those obtained from single variable analysis. For example, part of the effect of elevation commonly observed is due to lower temperature values at higher elevation. Consequently, the increasing effect of elevation on ozone seen in Figure 8 is the residual effect after controlling for all other variables including temperature, precipitation, spatial location and Julian day.

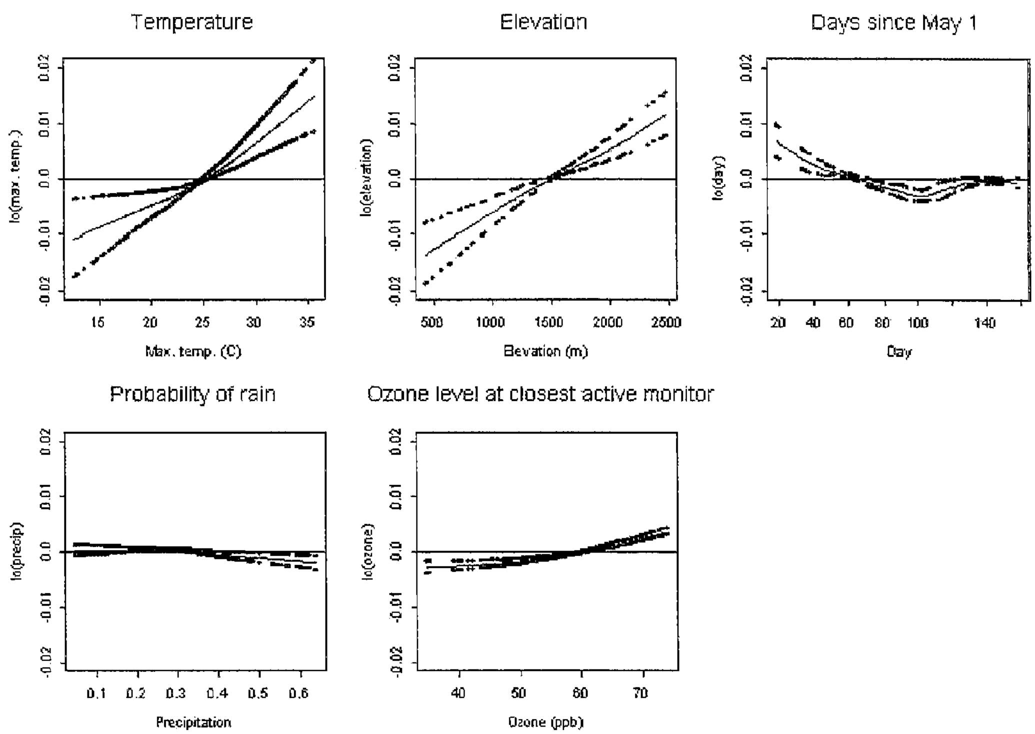

Figure 8. *Estimated conditional effects (and 95% confidence bands) of the explanatory variables. Days since May 1 is the cumulative number of days from the beginning of the study. Notice that temperature and elevation have the greatest difference from the 0 line, indicating they are the most important explanatory variables in the analysis.*

Based upon the semivariogram analysis that was used to estimate prediction errors in the ESRI study (Figure 5), it was found that O_3 concentrations could be confidently estimated within a radius of 19 km from the nearest measurement site toward the direction where the extrapolation techniques would be required. The value of prediction standard error at that distance was about ±8.2 ppb-hr. This value indicates that most of the National Forest and National Park area of the Sierra Nevada was adequately covered by the sample locations used in this study (Figure 5). Only the southeastern and some of the central-eastern areas were not adequately sampled.

Maps of estimated probabilities for cumulative ozone levels for a period of 140 days starting May 25 indicate that the central- and south-western Sierra Nevada were likely to have been exposed to SUM0 values greater than 201.6 ppm (average 60 ppb-hr) (Figure 9). A south-eastern area of the Sierra Nevada also is estimated to have high exposure (SUM0>201.6 ppm) with 95% probabilities. This may be due to valley wind patterns transporting air pollution over the southern end of the Sierra Nevada, or northerly winds transporting air pollution from the Los Angeles Basin to the southeastern edge of the mountain range, or both.

These maps also may be useful as indicators of potential crown injury. Several previous studies (Miller et al., 1996; Salardino, 1996; Arbaugh et al., 1998) found linear relationships between ambient ozone and foliar injury in the Sierra Nevada. Thus a probability graph such as the SUM0>50 ppb-hr with 95% probabilities may be a possible predictor of FPM injury ratings, and the SUM0>60 ppb-hr with 95% probabilities may be an indicator of sites that have severe injury. Further analysis is needed, however, to confirm the usefulness of these maps for indicating spatial patterns of ozone injury.

High exposure risk areas did not always result in moderate or high injury to pines (Figure 10). It appeared that a clear relationship between exposure and injury only appeared when cumulative seasonal ambient ozone exceeded 60 ppb-hr. Site specific factors, such as aspect, soil water balance and phenotypic response by local populations also affect expression of visible injury (Arbaugh and others 1999, Grulke 1999). In addition differences in the experience or judgment of the evaluating crews can also affect the severity of injury reported.

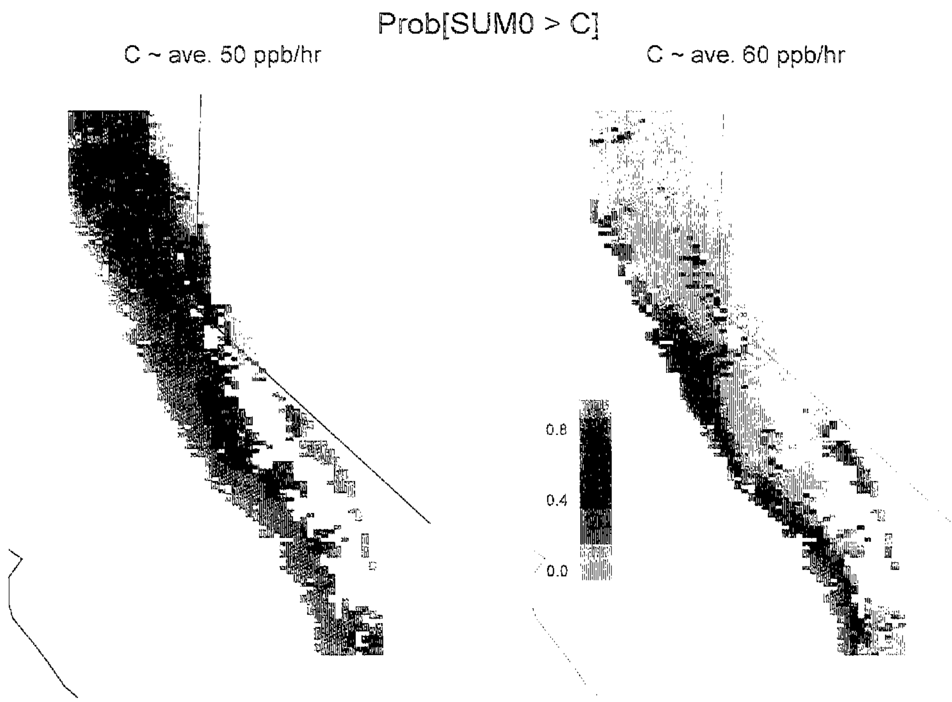

Figure 9. *Estimated probabilities of SUM0 values exceeding two critical levels, average seasonal ppb-hr >50 and >60. SUM0 was calculated for a period of 140 days starting May 25, 1999.*

A limitation of the FPM surveys became apparent during the analysis. The FPM surveys were located only on the western side of the Sierra Nevada, thus do not match the area of the passive ozone survey. While it is generally assumed that interior and eastern side sites have little or no injury due to ozone, the lack of data reduces our ability to quantify the spatial relationship between ambient ozone and foliar injury. This problem is a legacy of the FOREST system that was also designed for the western side of the Sierra Nevada.

Conclusions

Development of statistical models describing patterns of ambient ozone over space and time are now practical due to the development of low-cost passive sampler systems. In these initial modeling efforts a spatial model with an estimated of R^2 =58% and with an average standard deviation of 6.68 ppb-hour was obtained. Further improvements in the accuracy of predictions are possible because residual analysis indicates unexplained spatial patterns in the data.

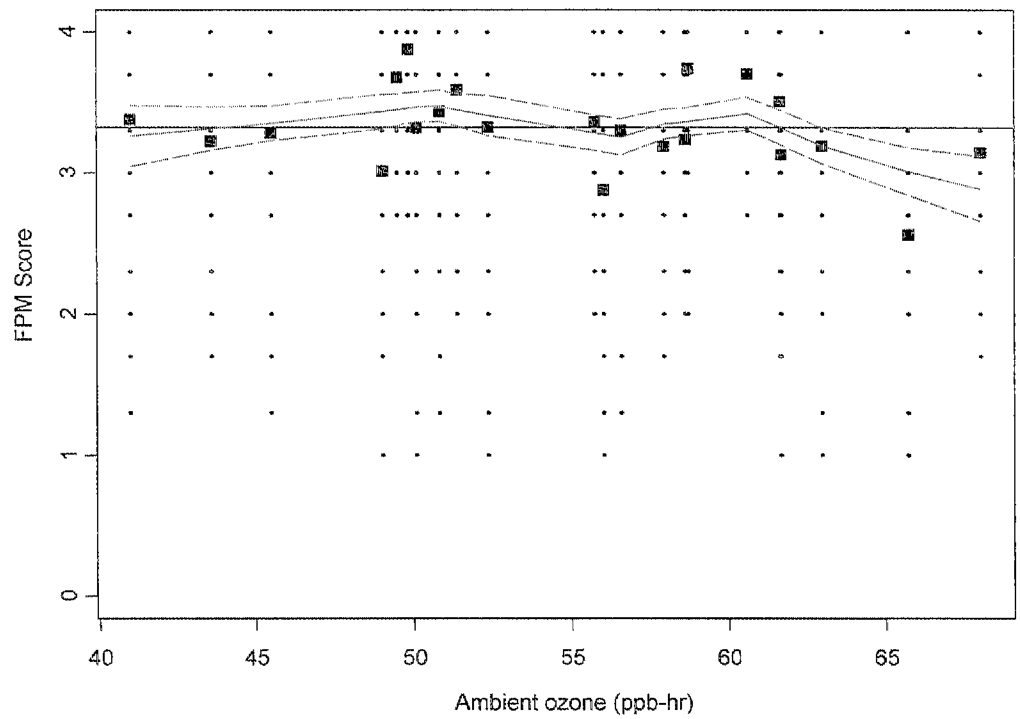

Figure 10. *Forest Pest Management (FPM) ozone injury scores (squares) compared with average seasonal ambient ozone (ppb-hr) estimated from passive samplers. All injury sites were within 2 miles of passive ozone samplers. Points are the individual two-week passive ozone values, the solid line is the average ambient ozone estimate, and the dashed line is the ± 2 standard errors.*

The results of these parallel studies also suggest that the majority of the study area was reliably estimated for the Sierra Nevada, although the distribution of the measurement sites could still be improved (there was clearly insufficient number of sites on the eastern side of the mountain range). The availability of the weather data and presence of strong correlations between maximum temperatures and elevation with O_3 contributed to lower sampling site densities being needed to obtain reliable spatial surface estimates in the Sierra Nevada.

In theory the best analytical choice for analysis depends on whether variation is local, which favors using Geostatistical approaches, or whether regional trends dominate the variation between sample locations, which indicates that localized regression may be more appropriate. Air pollution formation consists of multiple local processes, but regional atmospheric processes dominate transport in the San Joaquin Valley. Little information exists, however, about the effect of the complex topography and surface friction characteristics present in mountainous environments on large scale pollution transport. The lack of spatial autocorrelation after using locally weighted regression modeling indicate that large scale trends likely continue to dominate the variability. This conclusion is supported by the slightly lower variations resulting from the PSW analysis. In practice, however, the final spatial patterns developed from the analyses had few differences, especially if only significant spatial patterns are considered. This lack of difference may indicate that the choice of analysis approach may not be as important as a careful application of the approach chosen.

The design of the foliar survey segment of this study was less adequate. The distribution of the sample sites used in this study was not based on the spatial distribution of sensitive trees in the Sierra Nevada, rather centered around an existing network of sites located along the western side. Interior and eastside sites were not sampled, making it difficult to quantify the ability of the ozone exposure risk maps to estimate spatial patterns of ozone injury to sensitive pines.

The foliar survey information did have great value for developing future foliar survey work. Both Forest Health Management (Campbell and others 2000) and the Forest Service Air Quality Management (Air Resource Management 1998) are developing long-term foliar monitoring networks for the Sierra Nevada. The results of this study have had great value for design of these monitoring systems. In the future information from these networks will be used to develop models of spatial risk estimation to pine and understory plant injury based on patterns of ozone exposure.

Glossary of Acronyms

DEM Digital Elevation Model, the format of USGS digital elevation data sets used from map production in many GIS applications.

ESRI Environmental Systems Research Institute (ESRI), Redlands, California

FOREST The Forest Ozone REsponse STudy. The FOREST project was developed as a companion project to SCOIAS through an agreement between the Forest Service, Region 5, Air Resource Management and the California Air Resources Board. This agreement led to the establishment of forest vegetation plots in the vicinity of SCOIAS monitoring stations for the purpose of annual assessments of ozone injury to ponderosa and Jeffrey pine populations. Other participants, including Yosemite, Sequoia-Kings Canyon and Lassen Volcanic National Parks, joined FOREST by establishing and assessing tree conditions at three plots in each Park; and the Forest Service, Pacific Southwest Research Station, by including four years (1992-1995) of OII evaluations from three sites at Barton Flats in the San Bernardino Mountains.

FPM Forest Pest Management system for ozone injury evaluation of ponderosa and Jeffrey pines. The FPM method quantifies ozone injury by noting the youngest whorl of needles that shows chlorotic mottle. The index has a range from 0 to 4 for each tree. If there is injury on current year needles, the FPM score is 0. If there is no injury on the current year needles but injury on the 1-year old needles, the FPM score is 1. If there is no injury on either the current year or 1-year old needles, but there is injury on the 2-year old needles, the FPM score is 2. This evaluation is applied through the 4-year old needles, where if no injury has occurred, the FPM score is 4, and the tree is considered to be uninjured by ozone.

GIS Geographical Information System. A comprehensive set of software designed for the interpretation, analysis and display of spatially related data.

HRS80 The total number of hours in the exposure period equal to or greater than 80 ppb-hr of ozone.

OII Ozone Injury Index. The OII method (Miller and others 1996b) employs a five branch sample pruned from the lower crown of each ponderosa or Jeffrey pine. Several variables are counted, estimated visually or measured on each branch, namely, number of annual needle whorls, amount of chlorotic mottle on the needles of each annual whorl, and the length of needles in each annual whorl. Percent live crown is determined for each tree. These variables are entered into an algorithm for computing the OII for each tree (the range of the index is from 0 to 100 where higher values indicate more injury). The four main components used to compute the index are weighted as follows: needle whorl retention (40 percent), chlorotic mottle percent of each whorl (40 percent), needle length (10 percent) and percent live crown (10 percent).

PSW Pacific Southwest Research Station.

SBGS San Bernardino Mountains Air Pollution Gradient Study. A series of 18 sites established in 1972-1973 in the San Bernardino Mountains along a west to east gradient of air pollution by Paul Miller and Joe McBride. Periodic remeasurments and numerous cooperative studies at these sites have made them some of the most valuable long-term forest air pollution sites in the world.

SCOIAS The Sierra Cooperative Ozone Impact Assessment Study. SCOIAS's principal activity was to monitor ambient ozone and meteorological variables at six Sierra

Nevada sites (Van Ooy and Carrol 1995).

SNEP Sierra Nevada Ecosystem Study. A large scale program designed to assess the current status, and develop options for future management of ecosystems contained in the Sierra Nevada.

SPAM Sierra Provinces Assessment Monitoring. A Region 5, USDA - Forest Service, program to implement protection and monitoring programs in the Sierra Nevada, based on the results of SNEP

SUM0 The cumulative sum of all hourly ozone concentrations over an exposure period. In this report it is represented as a 24 hr sum of ppb-hr over either 2-week sample periods, or over the sampling season (May 12 – September 28).

SUM06 The sum of all ozone concentrations 60 ppb-hr or greater over the exposure period.

USEPA United States Environmental Protection Agency.

USGS United States Geological Survey.

W126 The sum of differentially weighted concentrations (40 and 60 ppb-hr concentrations are weighted using a sigmoidal function and concentrations above 100 ppb-hr are all given a weight of 1).

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Appendix A.

Table A-1. Ambient ozone sites, beginning and ending exposure dates, oxidation rates and corresponding estimate ambient ozone for sites used in this report. All samplers were changed on a two-week cycle except for samplers in Yosemite National Park, which were changed weekly to match existing National Park Service passive monitors.

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Ozone (ppb-hr)
Yosemite NP	Turtleback Dome	12-May	25-May	0.0164	0.0160	50.5
Yosemite NP	Turtleback Dome	1-Jun	8-Jun	0.0112	0.0114	35.2
Yosemite NP	Turtleback Dome	8-Jun	15-Jun	0.0180	0.0188	57.4
Yosemite NP	Turtleback Dome	15-Jun	22-Jun	0.0173	0.0177	54.6
Yosemite NP	Turtleback Dome	22-Jun	29-Jun	0.0186	0.0184	57.7
Yosemite NP	Turtleback Dome	29-Jun	6-Jul	0.0167	0.0167	52.1
Yosemite NP	Turtleback Dome	6-Jul	13-Jul	0.0187	0.0202	60.6
Yosemite NP	Turtleback Dome	13-Jul	20-Jul	0.0184	0.0182	57.1
Yosemite NP	Turtleback Dome	20-Jul	27-Jul	0.0193	0.0191	59.9
Yosemite NP	Turtleback Dome	27-Jul	3-Aug	0.0151	0.0152	47.2
Yosemite NP	Turtleback Dome	3-Aug	10-Aug	0.0149	0.0143	45.5
Yosemite NP	Turtleback Dome	10-Aug	17-Aug	0.0174	0.0175	54.4
Yosemite NP	Turtleback Dome	17-Aug	24-Aug	0.0183	0.0175	55.8
Yosemite NP	Turtleback Dome	24-Aug	31-Aug	0.0154	0.0160	49.0
Yosemite NP	Turtleback Dome	31-Aug	7-Sep	0.0197	0.0193	60.8
Yosemite NP	Turtleback Dome	7-Sep	14-Sep	0.0188	0.0189	58.8
Yosemite NP	Turtleback Dome	14-Sep	21-Sep	0.0188	0.0191	59.1
Yosemite NP	Turtleback Dome	21-Sep	28-Sep	0.0168	0.0150	49.6
Yosemite NP	Hodgdon Meadow	12-May	25-May	0.0089	0.0090	27.9
Yosemite NP	Hodgdon Meadow	1-Jun	8-Jun	0.0070	0.0069	21.7
Yosemite NP	Hodgdon Meadow	8-Jun	15-Jun	0.0094	0.0095	29.5
Yosemite NP	Hodgdon Meadow	15-Jun	22-Jun	0.0105	0.0092	30.7
Yosemite NP	Hodgdon Meadow	22-Jun	29-Jun	0.0112	0.0110	34.6
Yosemite NP	Hodgdon Meadow	29-Jun	6-Jul	0.0098	0.0098	30.6
Yosemite NP	Hodgdon Meadow	6-Jul	13-Jul	0.0103	0.0112	33.5
Yosemite NP	Hodgdon Meadow	13-Jul	20-Jul	0.0094	0.0088	28.4
Yosemite NP	Hodgdon Meadow	20-Jul	27-Jul	0.0106	0.0106	33.1
Yosemite NP	Hodgdon Meadow	27-Jul	3-Aug	0.0072	0.0087	24.8
Yosemite NP	Hodgdon Meadow	3-Aug	10-Aug	0.0080	0.0081	25.1

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Ozone (ppb-hr)
Yosemite NP	Hodgdon Meadow	10-Aug	17-Aug	0.0094	0.0089	28.5
Yosemite NP	Hodgdon Meadow	17-Aug	24-Aug	0.0093	0.0108	31.3
Yosemite NP	Hodgdon Meadow	24-Aug	31-Aug	0.0070	0.0078	23.1
Yosemite NP	Hodgdon Meadow	31-Aug	7-Sep	0.0102	0.0098	31.2
Yosemite NP	Hodgdon Meadow	7-Sep	14-Sep	0.0105	0.0107	33.1
Yosemite NP	Hodgdon Meadow	14-Sep	21-Sep	0.0093	0.0099	29.9
Yosemite NP	Hodgdon Meadow	21-Sep	28-Sep	0.0069	0.0068	21.4
Yosemite NP	Mosquito Creek	12-May	28-May	0.0132	0.0133	41.3
Yosemite NP	Mosquito Creek	3-Jun	10-Jun	0.0121	0.0118	37.3
Yosemite NP	Mosquito Creek	10-Jun	17-Jun	0.0173	0.0171	53.6
Yosemite NP	Mosquito Creek	17-Jun	24-Jun	0.0188	0.0181	57.5
Yosemite NP	Mosquito Creek	24-Jun	1-Jul	0.0176	0.0170	53.9
Yosemite NP	Mosquito Creek	1-Jul	8-Jul	0.0160	0.0170	51.4
Yosemite NP	Mosquito Creek	8-Jul	15-Jul	0.0182	0.0182	56.7
Yosemite NP	Mosquito Creek	15-Jul	22-Jul	0.0153	0.0176	51.3
Yosemite NP	Mosquito Creek	22-Jul	29-Jul	0.0226	0.0192	65.2
Yosemite NP	Mosquito Creek	29-Jul	5-Aug	0.0141	0.0146	44.7
Yosemite NP	Mosquito Creek	5-Aug	12-Aug	0.0122	0.0134	39.9
Yosemite NP	Mosquito Creek	12-Aug	19-Aug	0.0171	0.0173	53.6
Yosemite NP	Mosquito Creek	19-Aug	26-Aug	0.0184	0.0175	56.0
Yosemite NP	Mosquito Creek	26-Aug	2-Sep	0.0153	0.0154	47.9
Yosemite NP	Mosquito Creek	2-Sep	9-Sep	0.0191	0.0228	65.3
Yosemite NP	Mosquito Creek	9-Sep	16-Sep	0.0192	0.0203	61.6
Yosemite NP	Mosquito Creek	16-Sep	23-Sep	0.0170	0.0179	54.4
Yosemite NP	Mosquito Creek	23-Sep	30-Sep	0.0179	0.0175	55.2
Yosemite NP	El Portal	12-May	28-May	0.0108	0.0109	33.8
Yosemite NP	El Portal	3-Jun	10-Jun	0.0087	0.0086	27.0
Yosemite NP	El Portal	10-Jun	17-Jun	0.0140	0.0128	41.8
Yosemite NP	El Portal	17-Jun	24-Jun	0.0153	0.0145	46.5
Yosemite NP	El Portal	24-Jun	1-Jul	0.0141	0.0149	45.2
Yosemite NP	El Portal	1-Jul	8-Jul	0.0143	0.0143	44.6
Yosemite NP	El Portal	8-Jul	15-Jul	0.0171	0.0181	54.9
Yosemite NP	El Portal	15-Jul	22-Jul	0.0159	0.0127	44.6
Yosemite NP	El Portal	22-Jul	29-Jul	0.0160	0.0175	52.2
Yosemite NP	El Portal	29-Jul	5-Aug	0.0126	0.0118	38.0
Yosemite NP	El Portal	5-Aug	12-Aug	0.0116	0.0119	36.6
Yosemite NP	El Portal	12-Aug	19-Aug	0.0156	0.0153	48.2
Yosemite NP	El Portal	19-Aug	26-Aug	0.0146	0.0146	45.5
Yosemite NP	El Portal	26-Aug	2-Sep	0.0113	0.0131	38.0
Yosemite NP	El Portal	2-Sep	9-Sep	0.0169	0.0166	52.2
Yosemite NP	El Portal	9-Sep	16-Sep	0.0170	0.0168	52.7
Yosemite NP	El Portal	16-Sep	23-Sep	0.0152	0.0145	46.3
Yosemite NP	El Portal	23-Sep	30-Sep	0.0137	0.0164	46.9
Eldorado NF	Placerville Jail	13-May	26-May	0.0151	0.0156	47.9
Eldorado NF	Placerville Jail	26-May	9-Jun	0.0145	0.0138	44.1
Eldorado NF	Placerville Jail	9-Jun	23-Jun	0.0174	0.0185	56.0
Eldorado NF	Placerville Jail	23-Jun	7-Jul	0.0183	0.0178	56.3
Eldorado NF	Placerville Jail	7-Jul	21-Jul	0.0215	0.0225	68.6
Eldorado NF	Placerville Jail	21-Jul	4-Aug	0.0167	0.0170	52.5

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Ozone (ppb-hr)
Eldorado NF	Placerville Jail	4-Aug	18-Aug	0.0145	0.0146	45.4
Eldorado NF	Placerville Jail	18-Aug	1-Sep	0.0217	0.0201	65.2
Eldorado NF	Placerville Jail	1-Sep	15-Sep	0.0216	0.0211	66.6
Eldorado NF	Placerville Jail	15-Sep	29-Sep	0.0203	0.0199	62.7
Eldorado NF	Sly Park	13-May	26-May	0.0118	0.0119	36.9
Eldorado NF	Sly Park	26-May	9-Jun	0.0114	0.0115	35.7
Eldorado NF	Sly Park	9-Jun	23-Jun	0.0137	0.0129	41.5
Eldorado NF	Sly Park	23-Jun	7-Jul	0.0121	0.0126	38.5
Eldorado NF	Sly Park	7-Jul	21-Jul	0.0200	0.0190	60.8
Eldorado NF	Sly Park	21-Jul	4-Aug	0.0123	0.0119	37.7
Eldorado NF	Sly Park	4-Aug	18-Aug	0.0118	0.0118	36.8
Eldorado NF	Sly Park	18-Aug	1-Sep	0.0161	0.0166	51.0
Eldorado NF	Sly Park	1-Sep	15-Sep	0.0169	0.0170	52.9
Eldorado NF	Sly Park	15-Sep	29-Sep	0.0163	0.0168	51.6
Eldorado NF	Peavine/RivertonRidge	13-May	26-May	0.0159	0.0159	49.6
Eldorado NF	Peavine/RivertonRidge	26-May	9-Jun	0.0144	0.0146	45.2
Eldorado NF	Peavine/RivertonRidge	9-Jun	23-Jun	0.0171	0.0183	55.2
Eldorado NF	Peavine/RivertonRidge	23-Jun	7-Jul	0.0185	0.0179	56.7
Eldorado NF	Peavine/RivertonRidge	7-Jul	21-Jul	0.0200	0.0204	63.0
Eldorado NF	Peavine/RivertonRidge	21-Jul	4-Aug	0.0154	0.0166	49.9
Eldorado NF	Peavine/RivertonRidge	4-Aug	18-Aug	0.0153	0.0154	47.9
Eldorado NF	Peavine/RivertonRidge	18-Aug	1-Sep	0.0191	0.0187	58.9
Eldorado NF	Peavine/RivertonRidge	1-Sep	15-Sep	0.0198	0.0196	61.4
Eldorado NF	Peavine/RivertonRidge	15-Sep	29-Sep	0.0181	0.0188	57.5
Eldorado NF	Loon	26-May	9-Jun	0.0167	0.0162	51.3
Eldorado NF	Loon	9-Jun	23-Jun	0.0192	0.0252	69.2
Eldorado NF	Loon	23-Jun	7-Jul	0.0169	0.0179	54.3
Eldorado NF	Loon	7-Jul	21-Jul	0.0230	0.0237	72.8
Eldorado NF	Loon	21-Jul	4-Aug	0.0205	0.0194	62.2
Eldorado NF	Loon	4-Aug	18-Aug	0.0175	0.0162	52.5
Eldorado NF	Loon	18-Aug	1-Sep	0.0188	0.0183	57.8
Eldorado NF	Loon	1-Sep	15-Sep	0.0193	0.0203	61.7
Eldorado NF	Loon	15-Sep	29-Sep	0.0177	0.0172	54.4
Eldorado NF	Huckleberry	13-May	26-May	0.0137	0.0138	42.9
Eldorado NF	Huckleberry	26-May	9-Jun	0.0120	0.0129	38.8
Eldorado NF	Huckleberry	9-Jun	23-Jun	0.0121	0.0124	38.2
Eldorado NF	Huckleberry	23-Jun	7-Jul	0.0132	0.0137	41.9
Eldorado NF	Huckleberry	7-Jul	21-Jul	0.0139	0.0137	43.0
Eldorado NF	Huckleberry	21-Jul	4-Aug	0.0118	0.0120	37.1
Eldorado NF	Huckleberry	4-Aug	18-Aug	0.0095	0.0094	29.5
Eldorado NF	Huckleberry	18-Aug	1-Sep	0.0107	0.0108	33.5
Eldorado NF	Huckleberry	1-Sep	15-Sep	0.0116	0.0115	36.0
Eldorado NF	Huckleberry	15-Sep	29-Sep	0.0109	0.0107	33.7
Eldorado NF	Woodsford	13-May	26-May	0.0172	0.0197	57.5
Eldorado NF	Woodsford	26-May	9-Jun	0.0183	0.0173	55.5
Eldorado NF	Woodsford	9-Jun	23-Jun	0.0185	0.0188	58.2
Eldorado NF	Woodsford	23-Jun	7-Jul	0.0179	0.0233	64.2
Eldorado NF	Woodsford	7-Jul	21-Jul	0.0181	0.0188	57.5
Eldorado NF	Woodsford	21-Jul	4-Aug	0.0176	0.0167	53.5

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Ozone (ppb-hr)
Eldorado NF	Woodsford	4-Aug	18-Aug	0.0165	0.0145	48.3
Eldorado NF	Woodsford	18-Aug	1-Sep	0.0180	0.0188	57.4
Eldorado NF	Woodsford	1-Sep	15-Sep	0.0164	0.0170	52.1
Eldorado NF	Woodsford	15-Sep	29-Sep	0.0154	0.0148	47.1
Eldorado NF	Amador	13-May	26-May	0.0165	0.0162	51.0
Eldorado NF	Amador	26-May	9-Jun	0.0151	0.0149	46.8
Eldorado NF	Amador	9-Jun	23-Jun	0.0177	0.0180	55.7
Eldorado NF	Amador	23-Jun	7-Jul	0.0190	0.0179	57.5
Eldorado NF	Amador	7-Jul	21-Jul	0.0215	0.0223	68.3
Eldorado NF	Amador	21-Jul	4-Aug	0.0186	0.0177	56.6
Eldorado NF	Amador	4-Aug	18-Aug	0.0155	0.0153	48.0
Eldorado NF	Amador	18-Aug	1-Sep	0.0200	0.0196	61.7
Eldorado NF	Amador	1-Sep	15-Sep	0.0230	0.0206	68.0
Eldorado NF	Amador	15-Sep	29-Sep	0.0201	0.0203	63.0
Eldorado NF	Bear/Lumberyard	13-May	26-May	0.0173	0.0172	53.8
Eldorado NF	Bear/Lumberyard	26-May	9-Jun	0.0168	0.0164	51.8
Eldorado NF	Bear/Lumberyard	9-Jun	23-Jun	0.0186	0.0198	59.9
Eldorado NF	Bear/Lumberyard	23-Jun	7-Jul	0.0193	0.0195	60.5
Eldorado NF	Bear/Lumberyard	7-Jul	21-Jul	0.0211	0.0214	66.3
Eldorado NF	Bear/Lumberyard	21-Jul	4-Aug	0.0184	0.0186	57.7
Eldorado NF	Bear/Lumberyard	4-Aug	18-Aug	0.0162	0.0165	51.0
Eldorado NF	Bear/Lumberyard	18-Aug	1-Sep	0.0200	0.0196	61.7
Eldorado NF	Bear/Lumberyard	1-Sep	15-Sep	0.0213	0.0207	65.5
Eldorado NF	Bear/Lumberyard	15-Sep	29-Sep	0.0196	0.0199	61.6
Eldorado NF	Blodgett	13-May	27-May	0.0157	0.0156	48.8
Eldorado NF	Blodgett	27-May	9-Jun	0.0145	0.0146	45.4
Eldorado NF	Blodgett	10-Jun	24-Jun	0.0219	0.0186	63.1
Eldorado NF	Blodgett	24-Jun	8-Jul	0.0162	0.0141	47.2
Eldorado NF	Blodgett	8-Jul	22-Jul	0.0198	0.0202	62.4
Eldorado NF	Blodgett	22-Jul	4-Aug	0.0176	0.0174	54.6
Eldorado NF	Blodgett	4-Aug	19-Aug	0.0154	0.0150	47.4
Eldorado NF	Blodgett	19-Aug	2-Sep	0.0188	0.0231	65.3
Eldorado NF	Blodgett	2-Sep	16-Sep	0.0268	0.0208	74.2
Eldorado NF	Blodgett	16-Sep	29-Sep	0.0188	0.0183	57.8
Inyo NF	Grant Lake	26-May	10-Jun	0.0159	0.0150	48.2
Inyo NF	Grant Lake	10-Jun	23-Jun	0.0169	0.0177	53.9
Inyo NF	Grant Lake	23-Jun	7-Jul	0.0198	0.0230	66.7
Inyo NF	Grant Lake	7-Jul	22-Jul	0.0254	0.0188	68.9
Inyo NF	Grant Lake	22-Jul	4-Aug	0.0173	0.0166	52.9
Inyo NF	Grant Lake	4-Aug	18-Aug	0.0156	0.0156	48.6
Inyo NF	Grant Lake	18-Aug	1-Sep	0.0001	0.0000	NA
Inyo NF	Grant Lake	1-Sep	15-Sep	0.0355	0.0357	111.0
Inyo NF	Grant Lake	15-Sep	29-Sep	0.0129	0.0130	40.4
Inyo NF	Deadman Summit	26-May	10-Jun	0.0149	0.0155	47.4
Inyo NF	Deadman Summit	10-Jun	23-Jun	0.0175	0.0171	53.9
Inyo NF	Deadman Summit	23-Jun	7-Jul	0.0216	0.0204	65.5
Inyo NF	Deadman Summit	7-Jul	22-Jul	0.0189	0.0181	57.7
Inyo NF	Deadman Summit	22-Jul	4-Aug	0.0148	0.0142	45.2
Inyo NF	Deadman Summit	4-Aug	18-Aug	0.0137	0.0137	42.7

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Ozone (ppb-hr)
Inyo NF	Deadman Summit	18-Aug	1-Sep	0.0141	0.0151	45.5
Inyo NF	Deadman Summit	1-Sep	15-Sep	0.0138	0.0135	42.6
Inyo NF	Deadman Summit	15-Sep	29-Sep	0.0103	0.0101	31.8
Inyo NF	Minaret Vista	26-May	10-Jun	0.0177	0.0339	80.4
Inyo NF	Minaret Vista	10-Jun	23-Jun	0.0229	0.0249	74.5
Inyo NF	Minaret Vista	23-Jun	7-Jul	0.0266	0.0189	70.9
Inyo NF	Minaret Vista	7-Jul	22-Jul	0.0279	0.0296	89.6
Inyo NF	Minaret Vista	22-Jul	4-Aug	0.0204	0.0221	66.3
Inyo NF	Minaret Vista	4-Aug	18-Aug	0.0189	0.0180	57.5
Inyo NF	Minaret Vista	18-Aug	1-Sep	0.0209	0.0206	64.7
Inyo NF	Minaret Vista	1-Sep	15-Sep	0.0195	0.0204	62.2
Inyo NF	Minaret Vista	15-Sep	29-Sep	0.0183	0.0177	56.1
Inyo NF	Sherwin	26-May	10-Jun	0.0191	0.0165	55.5
Inyo NF	Sherwin	10-Jun	23-Jun	0.0210	0.0220	67.0
Inyo NF	Sherwin	23-Jun	7-Jul	0.0130	0.0252	59.6
Inyo NF	Sherwin	7-Jul	22-Jul	0.0285	0.0348	98.7
Inyo NF	Sherwin	22-Jul	4-Aug	0.0039	0.0214	39.4
Inyo NF	Sherwin	4-Aug	18-Aug	0.0168	0.0212	59.2
Inyo NF	Sherwin	18-Aug	1-Sep	0.0199	0.0195	61.4
Inyo NF	Sherwin	1-Sep	15-Sep	0.0179	0.0184	56.6
Inyo NF	Sherwin	15-Sep	29-Sep	0.0140	0.0144	44.3
Inyo NF	Rovana	26-May	10-Jun	0.0164	0.0153	49.4
Inyo NF	Rovana	10-Jun	23-Jun	0.0227	0.0198	66.3
Inyo NF	Rovana	23-Jun	7-Jul	0.0122	0.0161	44.1
Inyo NF	Rovana	7-Jul	22-Jul	0.0247	0.0201	69.8
Inyo NF	Rovana	22-Jul	4-Aug	0.0184	0.0199	59.7
Inyo NF	Rovana	4-Aug	18-Aug	0.0161	0.0158	49.7
Inyo NF	Rovana	18-Aug	1-Sep	0.0186	0.0203	60.6
Inyo NF	Rovana	1-Sep	15-Sep	0.0166	0.0164	51.4
Inyo NF	Rovana	15-Sep	29-Sep	0.0148	0.0147	46.0
Inyo NF	Sage Flat	30-Jul	18-Aug	0.0187	0.0188	58.5
Inyo NF	Sage Flat	18-Aug	1-Sep	0.0205	0.0198	62.8
Inyo NF	Sage Flat	1-Sep	15-Sep	0.0184	0.0182	57.1
Inyo NF	Sage Flat	15-Sep	29-Sep	0.0167	0.0162	51.3
Inyo NF	Sage Flat	29-Sep	13-Oct	0.0150	0.0173	50.4
Lassen NP	Manzanita Lake	10-Jun	23-Jun	0.0147	0.0146	45.7
Lassen NP	Manzanita Lake	23-Jun	7-Jul	0.0134	0.0132	41.5
Lassen NP	Manzanita Lake	7-Jul	21-Jul	0.0154	0.0151	47.5
Lassen NP	Manzanita Lake	21-Jul	4-Aug	0.0137	0.0133	42.1
Lassen NP	Manzanita Lake	4-Aug	19-Aug	0.0113	0.0109	34.6
Lassen NP	Manzanita Lake	19-Aug	1-Sep	0.0137	0.0136	42.6
Lassen NP	Manzanita Lake	1-Sep	16-Sep	0.0127	0.0131	40.2
Lassen NP	Manzanita Lake	16-Sep	30-Sep	0.0150	0.0152	47.1
Lassen NP	Summit Lake	23-Jun	7-Jul	0.0103	0.0105	32.4
Lassen NP	Summit Lake	7-Jul	21-Jul	0.0109	0.0112	34.5
Lassen NP	Summit Lake	21-Jul	4-Aug	0.0108	0.0113	34.5
Lassen NP	Summit Lake	4-Aug	19-Aug	0.0084	0.0087	26.7
Lassen NP	Summit Lake	19-Aug	1-Sep	0.0097	0.0099	30.6
Lassen NP	Summit Lake	1-Sep	16-Sep	0.0095	0.0092	29.2

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Ozone (ppb-hr)
Lassen NP	Summit Lake	16-Sep	30-Sep	0.0112	0.0116	35.5
Lassen NP	Diamond Peak	10-Jun	23-Jun	0.0185	0.0195	59.2
Lassen NP	Diamond Peak	23-Jun	7-Jul	0.0149	0.0151	46.8
Lassen NP	Diamond Peak	7-Jul	21-Jul	0.0168	0.0172	53.0
Lassen NP	Diamond Peak	21-Jul	4-Aug	0.0168	0.0157	50.7
Lassen NP	Diamond Peak	4-Aug	19-Aug	0.0143	0.0145	44.9
Lassen NP	Diamond Peak	19-Aug	1-Sep	0.0173	0.0180	55.0
Lassen NP	Diamond Peak	1-Sep	16-Sep	0.0160	0.0166	50.8
Lassen NP	Diamond Peak	16-Sep	30-Sep	0.0182	0.0180	56.4
Lassen NF	Hatchet Mountain	12-May	27-May	0.0157	0.0160	49.4
Lassen NF	Hatchet Mountain	27-May	10-Jun	0.0146	0.0137	44.1
Lassen NF	Hatchet Mountain	10-Jun	24-Jun	0.0158	0.0151	48.2
Lassen NF	Hatchet Mountain	24-Jun	8-Jul	0.0131	0.0130	40.7
Lassen NF	Hatchet Mountain	8-Jul	22-Jul	0.0178	0.0186	56.7
Lassen NF	Hatchet Mountain	22-Jul	5-Aug	0.0172	0.0166	52.7
Lassen NF	Hatchet Mountain	5-Aug	19-Aug	0.0137	0.0147	44.3
Lassen NF	Hatchet Mountain	19-Aug	2-Sep	0.0161	0.0161	50.2
Lassen NF	Hatchet Mountain	2-Sep	16-Sep	0.0163	0.0156	49.7
Lassen NF	Hatchet Mountain	16-Sep	30-Sep	0.0172	0.0160	51.8
Lassen NF	Hat Creek	12-May	27-May	0.0153	0.0150	47.2
Lassen NF	Hat Creek	27-May	10-Jun	0.0134	0.0137	42.2
Lassen NF	Hat Creek	10-Jun	24-Jun	0.0156	0.0143	46.6
Lassen NF	Hat Creek	24-Jun	8-Jul	0.0129	0.0128	40.1
Lassen NF	Hat Creek	8-Jul	22-Jul	0.0159	0.0159	49.6
Lassen NF	Hat Creek	22-Jul	5-Aug	0.0161	0.0149	48.3
Lassen NF	Hat Creek	5-Aug	19-Aug	0.0134	0.0138	42.4
Lassen NF	Hat Creek	19-Aug	2-Sep	0.0158	0.0159	49.4
Lassen NF	Hat Creek	2-Sep	16-Sep	0.0155	0.0152	47.9
Lassen NF	Hat Creek	16-Sep	30-Sep	0.0150	0.0156	47.7
Lassen NF	Harvey Mountain	12-May	27-May	0.0160	0.0167	51.0
Lassen NF	Harvey Mountain	27-May	10-Jun	0.0141	0.0140	43.8
Lassen NF	Harvey Mountain	10-Jun	24-Jun	0.0159	0.0165	50.5
Lassen NF	Harvey Mountain	24-Jun	8-Jul	0.0131	0.0139	42.1
Lassen NF	Harvey Mountain	8-Jul	22-Jul	0.0175	0.0179	55.2
Lassen NF	Harvey Mountain	22-Jul	5-Aug	0.0164	0.0160	50.5
Lassen NF	Harvey Mountain	5-Aug	19-Aug	0.0147	0.0151	46.5
Lassen NF	Harvey Mountain	19-Aug	2-Sep	0.0159	0.0162	50.0
Lassen NF	Harvey Mountain	2-Sep	16-Sep	0.0160	0.0158	49.6
Lassen NF	Harvey Mountain	16-Sep	30-Sep	0.0159	0.0161	49.9
Lassen NF	Pine Creek Valley	12-May	27-May	0.0120	0.0131	39.1
Lassen NF	Pine Creek Valley	27-May	10-Jun	0.0117	0.0128	38.2
Lassen NF	Pine Creek Valley	10-Jun	24-Jun	0.0121	0.0118	37.3
Lassen NF	Pine Creek Valley	24-Jun	8-Jul	0.0110	0.0104	33.4
Lassen NF	Pine Creek Valley	8-Jul	22-Jul	0.0114	0.0122	36.8
Lassen NF	Pine Creek Valley	22-Jul	5-Aug	0.0115	0.0113	35.5
Lassen NF	Pine Creek Valley	5-Aug	19-Aug	0.0103	0.0096	31.0
Lassen NF	Pine Creek Valley	19-Aug	2-Sep	0.0111	0.0119	35.9
Lassen NF	Pine Creek Valley	2-Sep	16-Sep	0.0101	0.0104	32.0
Lassen NF	Pine Creek Valley	16-Sep	30-Sep	0.0109	0.0113	34.6

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Ozone (ppb-hr)
Lassen NF	Little Fredonyer	12-May	26-May	0.0191	0.0167	55.8
Lassen NF	Little Fredonyer	27-May	10-Jun	0.0172	0.0159	51.6
Lassen NF	Little Fredonyer	10-Jun	23-Jun	0.0166	0.0183	54.4
Lassen NF	Little Fredonyer	23-Jun	7-Jul	0.0161	0.0144	47.5
Lassen NF	Little Fredonyer	7-Jul	21-Jul	0.0176	0.0189	56.9
Lassen NF	Little Fredonyer	21-Jul	4-Aug	0.0168	0.0177	53.8
Lassen NF	Little Fredonyer	4-Aug	18-Aug	0.0149	0.0155	47.4
Lassen NF	Little Fredonyer	18-Aug	1-Sep	0.0174	0.0174	54.3
Lassen NF	Little Fredonyer	1-Sep	15-Sep	0.0166	0.0167	51.9
Lassen NF	Little Fredonyer	15-Sep	29-Sep	0.0162	0.0156	49.6
Lassen NF	Paynes Creek	13-May	26-May	0.0170	0.0175	53.8
Lassen NF	Paynes Creek	26-May	9-Jun	0.0158	0.0165	50.4
Lassen NF	Paynes Creek	9-Jun	23-Jun	0.0181	0.0171	54.9
Lassen NF	Paynes Creek	23-Jun	7-Jul	0.0164	0.0148	48.6
Lassen NF	Paynes Creek	7-Jul	21-Jul	0.0203	0.0207	63.9
Lassen NF	Paynes Creek	21-Jul	4-Aug	0.0190	0.0187	58.8
Lassen NF	Paynes Creek	4-Aug	18-Aug	0.0162	0.0167	51.3
Lassen NF	Paynes Creek	18-Aug	1-Sep	0.0208	0.0215	65.9
Lassen NF	Paynes Creek	1-Sep	15-Sep	0.0213	0.0201	64.5
Lassen NF	Paynes Creek	15-Sep	29-Sep	0.0171	0.0184	55.3
Lassen NF	Mineral	13-May	26-May	0.0143	0.0145	44.9
Lassen NF	Mineral	26-May	9-Jun	0.0133	0.0128	40.7
Lassen NF	Mineral	9-Jun	23-Jun	0.0146	0.0148	45.8
Lassen NF	Mineral	23-Jun	7-Jul	0.0135	0.0135	42.1
Lassen NF	Mineral	7-Jul	21-Jul	0.0163	0.0165	51.1
Lassen NF	Mineral	21-Jul	4-Aug	0.0152	0.0178	51.4
Lassen NF	Mineral	4-Aug	18-Aug	0.0129	0.0133	40.8
Lassen NF	Mineral	18-Aug	1-Sep	0.0168	0.0167	52.2
Lassen NF	Mineral	1-Sep	15-Sep	0.0160	0.0160	49.9
Lassen NF	Mineral	15-Sep	29-Sep	0.0151	0.0139	45.2
Lassen NF	Butte Meadows	13-May	26-May	0.0148	0.0157	47.5
Lassen NF	Butte Meadows	26-May	9-Jun	0.0138	0.0142	43.7
Lassen NF	Butte Meadows	9-Jun	23-Jun	0.0159	0.0140	46.6
Lassen NF	Butte Meadows	23-Jun	7-Jul	0.0135	0.0110	38.2
Lassen NF	Butte Meadows	7-Jul	21-Jul	0.0180	0.0175	55.3
Lassen NF	Butte Meadows	21-Jul	4-Aug	0.0160	0.0152	48.6
Lassen NF	Butte Meadows	4-Aug	18-Aug	0.0129	0.0138	41.6
Lassen NF	Butte Meadows	18-Aug	1-Sep	0.0174	0.0171	53.8
Lassen NF	Butte Meadows	1-Sep	15-Sep	0.0167	0.0167	52.1
Lassen NF	Butte Meadows	15-Sep	29-Sep	0.0160	0.0149	48.2
Lassen NF	Canyon Dam	13-May	26-May	0.0166	0.0158	50.5
Lassen NF	Canyon Dam	26-May	9-Jun	0.0146	0.0147	45.7
Lassen NF	Canyon Dam	9-Jun	23-Jun	0.0148	0.0150	46.5
Lassen NF	Canyon Dam	23-Jun	7-Jul	0.0137	0.0143	43.7
Lassen NF	Canyon Dam	7-Jul	21-Jul	0.0170	0.0175	53.8
Lassen NF	Canyon Dam	21-Jul	4-Aug	0.0147	0.0166	48.8
Lassen NF	Canyon Dam	4-Aug	18-Aug	0.0145	0.0142	44.7
Lassen NF	Canyon Dam	18-Aug	1-Sep	0.0166	0.0173	52.9
Lassen NF	Canyon Dam	1-Sep	15-Sep	0.0169	0.0174	53.5

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Ozone (ppb-hr)
Lassen NF	Canyon Dam	15-Sep	29-Sep	0.0168	0.0166	52.1
Plumas NF	Jarbo Gap/Flea Mtn.	12-May	26-May	0.0190	0.0174	56.7
Plumas NF	Jarbo Gap/Flea Mtn.	26-May	9-Jun	0.0197	0.0224	65.6
Plumas NF	Jarbo Gap/Flea Mtn.	9-Jun	23-Jun	0.0188	0.0182	57.7
Plumas NF	Jarbo Gap/Flea Mtn.	23-Jun	7-Jul	0.0164	0.0164	51.1
Plumas NF	Jarbo Gap/Flea Mtn.	7-Jul	21-Jul	0.0268	0.0216	75.5
Plumas NF	Jarbo Gap/Flea Mtn.	21-Jul	4-Aug	0.0187	0.0192	59.1
Plumas NF	Jarbo Gap/Flea Mtn.	4-Aug	18-Aug	0.0144	0.0150	45.8
Plumas NF	Jarbo Gap/Flea Mtn.	18-Aug	1-Sep	0.0172	0.0177	54.4
Plumas NF	Jarbo Gap/Flea Mtn.	1-Sep	15-Sep	0.0164	0.0162	50.8
Plumas NF	Jarbo Gap/Flea Mtn.	15-Sep	29-Sep	0.0172	0.0169	53.2
Plumas NF	Bucks Lake	26-May	9-Jun	0.0140	0.0139	43.5
Plumas NF	Bucks Lake	9-Jun	23-Jun	0.0150	0.0147	46.3
Plumas NF	Bucks Lake	23-Jun	7-Jul	0.0151	0.0145	46.1
Plumas NF	Bucks Lake	7-Jul	21-Jul	0.0170	0.0173	53.5
Plumas NF	Bucks Lake	21-Jul	4-Aug	0.0169	0.0168	52.5
Plumas NF	Bucks Lake	4-Aug	18-Aug	0.0132	0.0137	41.9
Plumas NF	Bucks Lake	18-Aug	1-Sep	0.0142	0.0138	43.7
Plumas NF	Bucks Lake	1-Sep	15-Sep	0.0122	0.0121	37.9
Plumas NF	Bucks Lake	15-Sep	29-Sep	0.0145	0.0147	45.5
Plumas NF	Quincy	12-May	26-May	0.0162	0.0168	51.4
Plumas NF	Quincy	26-May	9-Jun	0.0134	0.0139	42.6
Plumas NF	Quincy	9-Jun	23-Jun	0.0152	0.0167	49.7
Plumas NF	Quincy	23-Jun	7-Jul	0.0155	0.0150	47.5
Plumas NF	Quincy	7-Jul	21-Jul	0.0179	0.0170	54.4
Plumas NF	Quincy	21-Jul	4-Aug	0.0162	0.0163	50.7
Plumas NF	Quincy	4-Aug	18-Aug	0.0136	0.0142	43.3
Plumas NF	Quincy	18-Aug	1-Sep	0.0170	0.0168	52.7
Plumas NF	Quincy	1-Sep	15-Sep	0.0172	0.0169	53.2
Plumas NF	Quincy	15-Sep	29-Sep	0.0144	0.0139	44.1
Plumas NF	Antelope Lake	12-May	26-May	0.0120	0.0131	39.1
Plumas NF	Antelope Lake	26-May	9-Jun	0.0119	0.0128	38.5
Plumas NF	Antelope Lake	9-Jun	23-Jun	0.0120	0.0121	37.6
Plumas NF	Antelope Lake	23-Jun	7-Jul	0.0121	0.0121	37.7
Plumas NF	Antelope Lake	7-Jul	21-Jul	0.0114	0.0121	36.6
Plumas NF	Antelope Lake	21-Jul	4-Aug	0.0123	0.0120	37.9
Plumas NF	Antelope Lake	4-Aug	18-Aug	0.0101	0.0103	31.8
Plumas NF	Antelope Lake	18-Aug	2-Sep	0.0129	0.0125	39.6
Plumas NF	Antelope Lake	2-Sep	15-Sep	0.0126	0.0118	38.0
Plumas NF	Antelope Lake	15-Sep	29-Sep	0.0115	0.0105	34.3
Plumas NF	Pike County Peak Lookout	12-May	26-May	0.0181	0.0176	55.7
Plumas NF	Pike County Peak Lookout	26-May	9-Jun	0.0164	0.0156	49.9
Plumas NF	Pike County Peak Lookout	9-Jun	23-Jun	0.0186	0.0178	56.7
Plumas NF	Pike County Peak Lookout	23-Jun	7-Jul	0.0173	0.0177	54.6
Plumas NF	Pike County Peak Lookout	7-Jul	21-Jul	0.0201	0.0203	63.0
Plumas NF	Pike County Peak Lookout	21-Jul	4-Aug	0.0191	0.0196	60.3
Plumas NF	Pike County Peak Lookout	4-Aug	18-Aug	0.0159	0.0155	49.0
Plumas NF	Pike County Peak Lookout	18-Aug	1-Sep	0.0197	0.0200	61.9
Plumas NF	Pike County Peak Lookout	1-Sep	15-Sep	0.0197	0.0200	61.9

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Ozone (ppb-hr)
Plumas NF	Pike County Peak Lookout	15-Sep	29-Sep	0.0195	0.0197	61.1
Plumas NF	Little Grass Vally Reservoir	26-May	9-Jun	0.0147	0.0136	44.1
Plumas NF	Little Grass Vally Reservoir	9-Jun	23-Jun	0.0155	0.0147	47.1
Plumas NF	Little Grass Vally Reservoir	23-Jun	7-Jul	0.0155	0.0145	46.8
Plumas NF	Little Grass Vally Reservoir	7-Jul	21-Jul	0.0174	0.0172	53.9
Plumas NF	Little Grass Vally Reservoir	21-Jul	4-Aug	0.0157	0.0166	50.4
Plumas NF	Little Grass Vally Reservoir	4-Aug	18-Aug	0.0135	0.0136	42.2
Plumas NF	Little Grass Vally Reservoir	18-Aug	1-Sep	0.0153	0.0145	46.5
Plumas NF	Little Grass Vally Reservoir	1-Sep	15-Sep	0.0155	0.0154	48.2
Plumas NF	Little Grass Vally Reservoir	15-Sep	29-Sep	0.0156	0.0156	48.6
Plumas NF	Clover Valley	12-May	26-May	0.0124	0.0140	41.2
Plumas NF	Clover Valley	26-May	9-Jun	0.0130	0.0144	42.7
Plumas NF	Clover Valley	9-Jun	23-Jun	0.0143	0.0134	43.2
Plumas NF	Clover Valley	23-Jun	7-Jul	0.0141	0.0137	43.3
Plumas NF	Clover Valley	7-Jul	21-Jul	0.0146	0.0145	45.4
Plumas NF	Clover Valley	21-Jul	4-Aug	0.0136	0.0134	42.1
Plumas NF	Clover Valley	4-Aug	18-Aug	0.0114	0.0116	35.9
Plumas NF	Clover Valley	18-Aug	2-Sep	0.0136	0.0133	41.9
Plumas NF	Clover Valley	2-Sep	15-Sep	0.0131	0.0131	40.8
Plumas NF	Clover Valley	15-Sep	29-Sep	0.0117	0.0114	36.0
Sequoia NF	Scicon	12-May	26-May	0.0185	0.0177	56.4
Sequoia NF	Scicon	26-May	9-Jun	0.0005	0.0004	NA
Sequoia NF	Scicon	9-Jun	24-Jun	0.0262	0.0246	79.2
Sequoia NF	Scicon	24-Jun	7-Jul	0.0271	0.0265	83.6
Sequoia NF	Scicon	7-Jul	21-Jul	0.0238	0.0218	71.1
Sequoia NF	Scicon	21-Jul	4-Aug	0.0255	0.0251	78.9
Sequoia NF	Scicon	4-Aug	18-Aug	0.0201	0.0201	62.7
Sequoia NF	Scicon	18-Aug	1-Sep	0.0231	0.0233	72.3
Sequoia NF	Scicon	1-Sep	15-Sep	0.0259	0.0264	81.5
Sequoia NF	Scicon	15-Sep	29-Sep	0.0242	0.0252	77.0
Sequoia NF	Mountain Home	9-Jun	24-Jun	0.0400	NA	124.7
Sequoia NF	Mountain Home	24-Jun	7-Jul	0.0257	0.0224	75.0
Sequoia NF	Mountain Home	7-Jul	21-Jul	0.0183	0.0186	57.5
Sequoia NF	Mountain Home	21-Jul	4-Aug	0.0216	0.0221	68.1
Sequoia NF	Mountain Home	4-Aug	18-Aug	0.0154	0.0161	49.1
Sequoia NF	Mountain Home	18-Aug	1-Sep	0.0179	0.0192	57.8
Sequoia NF	Mountain Home	1-Sep	15-Sep	0.0207	0.0199	63.3
Sequoia NF	Mountain Home	15-Sep	29-Sep	0.0178	0.0181	56.0
Sequoia NF	North Road	10-Jun	24-Jun	0.0232	0.0210	68.9
Sequoia NF	North Road	24-Jun	8-Jul	0.0230	0.0212	68.9
Sequoia NF	North Road	8-Jul	21-Jul	0.0156	0.0145	46.9
Sequoia NF	North Road	21-Jul	4-Aug	0.0203	0.0203	63.3
Sequoia NF	North Road	4-Aug	19-Aug	0.0167	0.0167	52.1
Sequoia NF	North Road	18-Aug	1-Sep	0.0167	0.0149	49.3
Sequoia NF	North Road	1-Sep	17-Sep	0.0197	0.0201	62.0
Sequoia NF	North Road	17-Sep	29-Sep	0.0154	0.0164	49.6
Sequoia NF	Parker Pass	12-May	26-May	0.0176	0.0168	53.6
Sequoia NF	Parker Pass	26-May	9-Jun	0.0185	0.0188	58.2
Sequoia NF	Parker Pass	9-Jun	24-Jun	0.0205	0.0212	65.0

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Ozone (ppb-hr)
Sequoia NF	Parker Pass	24-Jun	8-Jul	0.0219	0.0204	65.9
Sequoia NF	Parker Pass	8-Jul	21-Jul	0.0150	0.0154	47.4
Sequoia NF	Parker Pass	21-Jul	4-Aug	0.0202	0.0202	63.0
Sequoia NF	Parker Pass	4-Aug	19-Aug	0.0151	0.0145	46.1
Sequoia NF	Parker Pass	18-Aug	1-Sep	0.0141	0.0144	44.4
Sequoia NF	Parker Pass	1-Sep	16-Sep	0.0184	0.0186	57.7
Sequoia NF	Parker Pass	16-Sep	29-Sep	0.0158	0.0159	49.4
Sequoia NF	Uhl Hill	12-May	26-May	0.0191	0.0184	58.5
Sequoia NF	Uhl Hill	26-May	9-Jun	0.0185	0.0170	55.3
Sequoia NF	Uhl Hill	9-Jun	24-Jun	0.0238	0.0266	78.6
Sequoia NF	Uhl Hill	24-Jun	8-Jul	0.0199	0.0237	68.0
Sequoia NF	Uhl Hill	8-Jul	21-Jul	0.0227	0.0223	70.2
Sequoia NF	Uhl Hill	21-Jul	4-Aug	0.0244	0.0251	77.2
Sequoia NF	Uhl Hill	4-Aug	19-Aug	0.0209	0.0196	63.1
Sequoia NF	Uhl Hill	18-Aug	1-Sep	0.0213	0.0205	65.2
Sequoia NF	Uhl Hill	1-Sep	16-Sep	0.0284	0.0290	89.5
Sequoia NF	Uhl Hill	16-Sep	29-Sep	0.0242	0.0243	75.6
Sequoia NF	Sherman	9-Jun	23-Jun	0.0234	0.0230	72.3
Sequoia NF	Sherman	23-Jun	7-Jul	0.0213	0.0209	65.8
Sequoia NF	Sherman	7-Jul	22-Jul	0.0167	0.0178	53.8
Sequoia NF	Sherman	22-Jul	4-Aug	0.0193	0.0177	57.7
Sequoia NF	Sherman	4-Aug	19-Aug	0.0156	0.0149	47.5
Sequoia NF	Sherman	1-Sep	16-Sep	0.0178	0.0190	57.4
Sequoia NF	Sherman	15-Sep	29-Sep	0.0146	0.0148	45.8
Sequoia NF	Blackrock	13-May	26-May	0.0193	0.0205	62.0
Sequoia NF	Blackrock	26-May	9-Jun	0.0165	0.0191	55.5
Sequoia NF	Blackrock	9-Jun	23-Jun	0.0229	0.0214	69.1
Sequoia NF	Blackrock	23-Jun	7-Jul	0.0205	0.0196	62.5
Sequoia NF	Blackrock	7-Jul	22-Jul	0.0168	0.0175	53.5
Sequoia NF	Blackrock	22-Jul	4-Aug	0.0175	0.0173	54.3
Sequoia NF	Blackrock	4-Aug	19-Aug	0.0148	0.0144	45.5
Sequoia NF	Blackrock	19-Aug	1-Sep	0.0195	0.0190	60.0
Sequoia NF	Blackrock	1-Sep	16-Sep	0.0191	0.0177	57.4
Sequoia NF	Blackrock	16-Sep	29-Sep	0.0146	0.0138	44.3
Sequoia NF	Fulton	13-May	26-May	0.0159	0.0172	51.6
Sequoia NF	Fulton	26-May	9-Jun	0.0151	0.0130	43.8
Sequoia NF	Fulton	9-Jun	23-Jun	0.0191	0.0190	59.4
Sequoia NF	Fulton	23-Jun	7-Jul	0.0212	0.0214	66.4
Sequoia NF	Fulton	7-Jul	21-Jul	0.0177	0.0187	56.7
Sequoia NF	Fulton	21-Jul	4-Aug	0.0191	0.0180	57.8
Sequoia NF	Fulton	4-Aug	19-Aug	0.0142	0.0142	44.3
Sequoia NF	Fulton	19-Aug	2-Sep	0.0200	NA	62.4
Sequoia NF	Fulton	2-Sep	15-Sep	0.0206	0.0207	64.4
Sequoia NF	Fulton	15-Sep	29-Sep	0.0187	0.0182	57.5
Sequoia NF	Greenhorn Summit	13-May	26-May	0.0169	0.0200	57.5
Sequoia NF	Greenhorn Summit	26-May	9-Jun	0.0209	0.0223	67.3
Sequoia NF	Greenhorn Summit	9-Jun	23-Jun	0.0488	0.0291	121.4
Sequoia NF	Greenhorn Summit	23-Jun	7-Jul	0.0293	0.0280	89.3
Sequoia NF	Greenhorn Summit	7-Jul	21-Jul	0.0239	0.0244	75.3

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Ozone (ppb-hr)
Sequoia NF	Greenhorn Summit	21-Jul	4-Aug	0.0247	0.0259	78.9
Sequoia NF	Greenhorn Summit	4-Aug	19-Aug	0.0198	0.0198	61.7
Sequoia NF	Greenhorn Summit	19-Aug	2-Sep	0.0246	0.0242	76.1
Sequoia NF	Greenhorn Summit	2-Sep	15-Sep	0.0254	0.0253	79.0
Sequoia NF	Greenhorn Summit	15-Sep	29-Sep	0.0210	NA	65.5
Sequoia NF	Grouse Springs/Breckenridge	13-May	26-May	0.0230	0.0235	72.5
Sequoia NF	Grouse Springs/Breckenridge	26-May	10-Jun	0.0184	0.0187	57.8
Sequoia NF	Grouse Springs/Breckenridge	10-Jun	23-Jun	0.0257	0.0254	79.7
Sequoia NF	Grouse Springs/Breckenridge	23-Jun	7-Jul	0.0244	0.0250	77.0
Sequoia NF	Grouse Springs/Breckenridge	7-Jul	21-Jul	0.0216	0.0212	66.7
Sequoia NF	Grouse Springs/Breckenridge	21-Jul	4-Aug	0.0225	0.0227	70.5
Sequoia NF	Grouse Springs/Breckenridge	4-Aug	19-Aug	0.0186	0.0182	57.4
Sequoia NF	Grouse Springs/Breckenridge	19-Aug	1-Sep	0.0234	0.0232	72.6
Sequoia NF	Grouse Springs/Breckenridge	1-Sep	15-Sep	0.0235	0.0235	73.3
Sequoia NF	Grouse Springs/Breckenridge	15-Sep	30-Sep	0.0198	0.0195	61.3
Sequoia NF	Havilah/Lightner	13-May	26-May	0.0235	0.0258	76.9
Sequoia NF	Havilah/Lightner	26-May	10-Jun	0.0206	0.0222	66.7
Sequoia NF	Havilah/Lightner	10-Jun	23-Jun	0.0277	0.0292	88.7
Sequoia NF	Havilah/Lightner	23-Jun	7-Jul	0.0264	0.0281	85.0
Sequoia NF	Havilah/Lightner	7-Jul	21-Jul	0.0225	0.0238	72.2
Sequoia NF	Havilah/Lightner	21-Jul	4-Aug	0.0244	0.0251	77.2
Sequoia NF	Havilah/Lightner	4-Aug	19-Aug	0.0200	0.0212	64.2
Sequoia NF	Havilah/Lightner	19-Aug	1-Sep	0.0269	NA	83.9
Sequoia NF	Havilah/Lightner	1-Sep	15-Sep	0.0257	0.0251	79.2
Sequoia NF	Havilah/Lightner	15-Sep	30-Sep	0.0210	NA	65.5
Sequoia NF	Liebel/Piutes	13-May	26-May	0.0274	0.0331	94.3
Sequoia NF	Liebel/Piutes	26-May	10-Jun	0.0195	0.0188	59.7
Sequoia NF	Liebel/Piutes	10-Jun	23-Jun	0.0223	0.0220	69.1
Sequoia NF	Liebel/Piutes	23-Jun	7-Jul	0.0232	0.0219	70.3
Sequoia NF	Liebel/Piutes	7-Jul	21-Jul	0.0167	0.0200	57.2
Sequoia NF	Liebel/Piutes	21-Jul	4-Aug	0.0200	0.0202	62.7
Sequoia NF	Liebel/Piutes	4-Aug	19-Aug	0.0157	0.0155	48.6
Sequoia NF	Liebel/Piutes	19-Aug	1-Sep	0.0224	0.0227	70.3
Sequoia NF	Liebel/Piutes	1-Sep	15-Sep	0.0200	0.0185	60.0
Sequoia NF	Liebel/Piutes	15-Sep	30-Sep	0.0163	NA	50.8
Sierra NF	Usona	26-May	10-Jun	0.0051	0.0112	25.4
Sierra NF	Usona	10-Jun	23-Jun	0.0080	0.0096	27.4
Sierra NF	Usona	23-Jun	7-Jul	0.0104	0.0104	32.4
Sierra NF	Usona	7-Jul	22-Jul	0.0181	0.0172	55.0
Sierra NF	Usona	22-Jul	4-Aug	0.0170	0.0176	53.9
Sierra NF	Usona	4-Aug	18-Aug	0.0127	0.0116	37.9
Sierra NF	Usona	18-Aug	1-Sep	0.0002	0.0197	31.0
Sierra NF	Usona	1-Sep	15-Sep	0.0221	0.0208	66.9
Sierra NF	Usona	15-Sep	30-Sep	0.0213	0.0223	68.0
Sierra NF	Poison Meadow	26-May	9-Jun	0.0073	0.0114	29.2
Sierra NF	Poison Meadow	9-Jun	23-Jun	0.0149	0.0173	50.2
Sierra NF	Poison Meadow	23-Jun	7-Jul	0.0106	0.0110	33.7
Sierra NF	Poison Meadow	7-Jul	22-Jul	0.0186	0.0183	57.5

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Ozone (ppb-hr)
Sierra NF	Poison Meadow	22-Jul	4-Aug	0.0172	0.0184	55.5
Sierra NF	Poison Meadow	4-Aug	18-Aug	0.0150	0.0149	46.6
Sierra NF	Poison Meadow	18-Aug	1-Sep	0.0003	0.0229	36.2
Sierra NF	Poison Meadow	1-Sep	15-Sep	0.0418	0.0418	130.3
Sierra NF	Poison Meadow	15-Sep	30-Sep	0.0201	0.0203	63.0
Sierra NF	Granite	12-May	26-May	0.0063	0.0046	17.0
Sierra NF	Granite	9-Jun	23-Jun	0.0058	0.0099	24.5
Sierra NF	Granite	23-Jun	7-Jul	0.0049	0.0088	21.4
Sierra NF	Granite	7-Jul	22-Jul	0.0104	0.0105	32.6
Sierra NF	Granite	22-Jul	4-Aug	0.0121	0.0110	36.0
Sierra NF	Granite	4-Aug	18-Aug	0.0101	0.0082	28.5
Sierra NF	Granite	18-Aug	1-Sep	0.0135	0.0130	41.3
Sierra NF	Granite	1-Sep	15-Sep	0.0132	0.0139	42.2
Sierra NF	Granite	15-Sep	30-Sep	0.0114	0.0114	35.5
Sierra NF	Auberry	12-May	26-May	0.0185	0.0188	58.2
Sierra NF	Auberry	26-May	9-Jun	0.0146	0.0152	46.5
Sierra NF	Auberry	9-Jun	23-Jun	0.0207	0.0194	62.5
Sierra NF	Auberry	23-Jun	7-Jul	0.0212	0.0210	65.8
Sierra NF	Auberry	7-Jul	21-Jul	0.0225	0.0246	73.4
Sierra NF	Auberry	21-Jul	4-Aug	0.0213	0.0211	66.1
Sierra NF	Auberry	4-Aug	18-Aug	0.0168	0.0166	52.1
Sierra NF	Auberry	18-Aug	1-Sep	0.0204	0.0206	63.9
Sierra NF	Auberry	1-Sep	15-Sep	0.0230	0.0221	70.3
Sierra NF	Auberry	15-Sep	29-Sep	0.0224	0.0225	70.0
Sierra NF	Shaver Lake	12-May	26-May	0.0181	0.0180	56.3
Sierra NF	Shaver Lake	26-May	9-Jun	0.0155	0.0158	48.8
Sierra NF	Shaver Lake	9-Jun	23-Jun	0.0174	0.0173	54.1
Sierra NF	Shaver Lake	23-Jun	7-Jul	0.0207	0.0209	64.9
Sierra NF	Shaver Lake	7-Jul	21-Jul	0.0197	0.0201	62.0
Sierra NF	Shaver Lake	21-Jul	4-Aug	0.0198	0.0200	62.0
Sierra NF	Shaver Lake	4-Aug	18-Aug	0.0168	0.0177	53.8
Sierra NF	Shaver Lake	18-Aug	1-Sep	0.0178	0.0178	55.5
Sierra NF	Shaver Lake	1-Sep	15-Sep	0.0199	0.0200	62.2
Sierra NF	Shaver Lake	15-Sep	29-Sep	0.0183	0.0188	57.8
Sierra NF	Kaiser	9-Jun	23-Jun	0.0181	0.0177	55.8
Sierra NF	Kaiser	23-Jun	7-Jul	0.0157	0.0158	49.1
Sierra NF	Kaiser	7-Jul	21-Jul	0.0152	0.0155	47.9
Sierra NF	Kaiser	21-Jul	4-Aug	0.0155	0.0149	47.4
Sierra NF	Kaiser	4-Aug	18-Aug	0.0146	0.0146	45.5
Sierra NF	Kaiser	18-Aug	1-Sep	0.0154	0.0150	47.4
Sierra NF	Kaiser	1-Sep	16-Sep	0.0162	0.0157	49.7
Sierra NF	Kaiser	16-Sep	29-Sep	0.0126	0.0122	38.7
Sierra NF	Trimmer	12-May	26-May	0.0175	0.0177	54.9
Sierra NF	Trimmer	26-May	9-Jun	0.0152	0.0151	47.2
Sierra NF	Trimmer	9-Jun	23-Jun	0.0198	0.0193	61.0
Sierra NF	Trimmer	23-Jun	7-Jul	0.0183	0.0223	63.3
Sierra NF	Trimmer	7-Jul	21-Jul	0.0205	0.0202	63.5
Sierra NF	Trimmer	21-Jul	4-Aug	0.0205	0.0203	63.6
Sierra NF	Trimmer	4-Aug	18-Aug	0.0165	0.0174	52.9

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Ozone (ppb-hr)
Sierra NF	Trimmer	18-Aug	1-Sep	0.0206	0.0205	64.1
Sierra NF	Trimmer	1-Sep	16-Sep	0.0242	0.0236	74.5
Sierra NF	Trimmer	16-Sep	29-Sep	0.0220	0.0226	69.5
Sierra NF	Teakettle	9-Jun	23-Jun	0.0178	0.0172	54.6
Sierra NF	Teakettle	23-Jun	7-Jul	0.0152	0.0156	48.0
Sierra NF	Teakettle	7-Jul	21-Jul	0.0147	0.0146	45.7
Sierra NF	Teakettle	21-Jul	4-Aug	0.0155	0.0153	48.0
Sierra NF	Teakettle	4-Aug	18-Aug	0.0132	0.0128	40.5
Sierra NF	Teakettle	18-Aug	1-Sep	0.0167	0.0153	49.9
Sierra NF	Teakettle	1-Sep	16-Sep	0.0157	0.0160	49.4
Sierra NF	Teakettle	16-Sep	29-Sep	0.0134	0.0132	41.5
Sierra NF	Courtright	9-Jun	23-Jun	0.0196	0.0209	63.1
Sierra NF	Courtright	23-Jun	7-Jul	0.0193	0.0208	62.5
Sierra NF	Courtright	7-Jul	21-Jul	0.0174	0.0186	56.1
Sierra NF	Courtright	21-Jul	4-Aug	0.0193	0.0188	59.4
Sierra NF	Courtright	4-Aug	18-Aug	0.0155	0.0154	48.2
Sierra NF	Courtright	18-Aug	1-Sep	0.0180	0.0180	56.1
Sierra NF	Courtright	1-Sep	16-Sep	0.0176	0.0175	54.7
Sierra NF	Courtright	16-Sep	29-Sep	0.0144	0.0149	45.7
Stanislaus NF	Avery	12-May	27-May	0.0179	0.0191	57.7
Stanislaus NF	Avery	27-May	9-Jun	0.0152	0.0162	49.0
Stanislaus NF	Avery	9-Jun	24-Jun	0.0168	0.0167	52.2
Stanislaus NF	Avery	24-Jun	7-Jul	0.0176	0.0193	57.5
Stanislaus NF	Avery	7-Jul	21-Jul	NA	0.0306	95.4
Stanislaus NF	Avery	21-Jul	4-Aug	0.0193	0.0210	62.8
Stanislaus NF	Avery	4-Aug	18-Aug	0.0293	0.0165	71.4
Stanislaus NF	Avery	18-Aug	1-Sep	0.0211	0.0216	66.6
Stanislaus NF	Avery	1-Sep	15-Sep	0.0231	0.0427	102.6
Stanislaus NF	Avery	15-Sep	29-Sep	0.0203	0.0196	62.2
Stanislaus NF	Hells Kitchen	12-May	27-May	0.0154	0.0153	47.9
Stanislaus NF	Hells Kitchen	27-May	9-Jun	0.0154	0.0143	46.3
Stanislaus NF	Hells Kitchen	9-Jun	24-Jun	0.0194	0.0204	62.0
Stanislaus NF	Hells Kitchen	24-Jun	7-Jul	0.0161	0.0168	51.3
Stanislaus NF	Hells Kitchen	7-Jul	21-Jul	0.0178	0.0179	55.7
Stanislaus NF	Hells Kitchen	21-Jul	4-Aug	0.0165	0.0162	51.0
Stanislaus NF	Hells Kitchen	4-Aug	18-Aug	0.0126	0.0134	40.5
Stanislaus NF	Hells Kitchen	18-Aug	1-Sep	0.0172	0.0171	53.5
Stanislaus NF	Hells Kitchen	1-Sep	15-Sep	0.0182	0.0174	55.5
Stanislaus NF	Hells Kitchen	15-Sep	29-Sep	0.0156	0.0155	48.5
Stanislaus NF	Ebbett's Pass	27-May	9-Jun	0.0189	0.0207	61.7
Stanislaus NF	Ebbett's Pass	9-Jun	24-Jun	0.0206	0.0207	64.4
Stanislaus NF	Ebbett's Pass	24-Jun	7-Jul	0.0214	0.0194	63.6
Stanislaus NF	Ebbett's Pass	7-Jul	21-Jul	0.0236	0.0246	75.1
Stanislaus NF	Ebbett's Pass	21-Jul	4-Aug	0.0229	0.0183	64.2
Stanislaus NF	Ebbett's Pass	4-Aug	18-Aug	0.0148	0.0152	46.8
Stanislaus NF	Ebbett's Pass	18-Aug	1-Sep	0.0189	0.0209	62.0
Stanislaus NF	Ebbett's Pass	1-Sep	15-Sep	0.0192	0.0198	60.8
Stanislaus NF	Ebbett's Pass	15-Sep	29-Sep	0.0168	0.0175	53.5
Stanislaus NF	Five Mile	12-May	27-May	0.0178	0.0178	55.5

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Ozone (ppb-hr)
Stanislaus NF	Five Mile	27-May	9-Jun	0.0152	0.0151	47.2
Stanislaus NF	Five Mile	9-Jun	23-Jun	0.0189	0.0180	57.5
Stanislaus NF	Five Mile	23-Jun	7-Jul	0.0185	0.0189	58.3
Stanislaus NF	Five Mile	7-Jul	21-Jul	0.0207	0.0231	68.3
Stanislaus NF	Five Mile	21-Jul	4-Aug	0.0193	0.0190	59.7
Stanislaus NF	Five Mile	4-Aug	18-Aug	0.0158	0.0156	49.0
Stanislaus NF	Five Mile	18-Aug	1-Sep	0.0195	0.0199	61.4
Stanislaus NF	Five Mile	1-Sep	15-Sep	NA	0.0221	68.9
Stanislaus NF	Five Mile	15-Sep	29-Sep	0.0206	0.0217	65.9
Stanislaus NF	Pinecrest	26-May	9-Jun	0.0122	0.0144	41.5
Stanislaus NF	Pinecrest	9-Jun	23-Jun	0.0212	0.0195	63.5
Stanislaus NF	Pinecrest	23-Jun	7-Jul	0.0184	0.0197	59.4
Stanislaus NF	Pinecrest	7-Jul	21-Jul	0.0183	0.0188	57.8
Stanislaus NF	Pinecrest	21-Jul	4-Aug	0.0154	0.0168	50.2
Stanislaus NF	Pinecrest	4-Aug	18-Aug	0.0161	0.0180	53.2
Stanislaus NF	Pinecrest	18-Aug	2-Sep	0.0166	0.0170	52.4
Stanislaus NF	Pinecrest	2-Sep	16-Sep	0.0214	0.0239	70.6
Stanislaus NF	Pinecrest	16-Sep	29-Sep	0.0187	0.0214	62.5
Stanislaus NF	Clark Fork	26-May	9-Jun	0.0105	0.0081	29.0
Stanislaus NF	Clark Fork	9-Jun	23-Jun	0.0131	0.0135	41.5
Stanislaus NF	Clark Fork	23-Jun	7-Jul	0.0124	0.0133	40.1
Stanislaus NF	Clark Fork	7-Jul	21-Jul	0.0135	0.0105	37.4
Stanislaus NF	Clark Fork	21-Jul	4-Aug	0.0121	0.0132	39.4
Stanislaus NF	Clark Fork	4-Aug	18-Aug	0.0089	0.0105	30.2
Stanislaus NF	Clark Fork	18-Aug	2-Sep	0.0100	0.0106	32.1
Stanislaus NF	Clark Fork	2-Sep	16-Sep	0.0175	0.0145	49.9
Stanislaus NF	Clark Fork	16-Sep	29-Sep	0.0125	0.0111	36.8
Stanislaus NF	Buck Meadow	12-May	26-May	0.0114	0.0102	33.7
Stanislaus NF	Buck Meadow	26-May	9-Jun	0.0143	0.0148	45.4
Stanislaus NF	Buck Meadow	9-Jun	23-Jun	0.0187	0.0180	57.2
Stanislaus NF	Buck Meadow	23-Jun	7-Jul	0.0178	0.0177	55.3
Stanislaus NF	Buck Meadow	7-Jul	21-Jul	0.0201	0.0190	61.0
Stanislaus NF	Buck Meadow	21-Jul	4-Aug	0.0143	0.0155	46.5
Stanislaus NF	Buck Meadow	4-Aug	18-Aug	0.0166	0.0100	41.5
Stanislaus NF	Buck Meadow	18-Aug	2-Sep	0.0137	0.0185	50.2
Stanislaus NF	Buck Meadow	2-Sep	16-Sep	0.0211	0.0216	66.6
Stanislaus NF	Buck Meadow	16-Sep	29-Sep	0.0183	0.0180	56.6
Stanislaus NF	Reed Creek	12-May	26-May	0.0110	0.0132	37.7
Stanislaus NF	Reed Creek	26-May	9-Jun	0.0111	0.0096	32.3
Stanislaus NF	Reed Creek	9-Jun	23-Jun	0.0130	0.0130	40.5
Stanislaus NF	Reed Creek	23-Jun	7-Jul	0.0132	0.0134	41.5
Stanislaus NF	Reed Creek	7-Jul	21-Jul	0.0152	0.0160	48.6
Stanislaus NF	Reed Creek	21-Jul	4-Aug	0.0111	0.0112	34.8
Stanislaus NF	Reed Creek	4-Aug	18-Aug	0.0109	0.0062	26.7
Stanislaus NF	Reed Creek	18-Aug	2-Sep	0.0126	0.0127	39.4
Stanislaus NF	Reed Creek	2-Sep	16-Sep	0.0096	0.0143	37.3
Stanislaus NF	Reed Creek	16-Sep	29-Sep	0.0141	0.0149	45.2
Stanislaus NF	Sonora Pass	26-May	9-Jun	0.0095	0.0098	30.1
Stanislaus NF	Sonora Pass	9-Jun	23-Jun	0.0040	0.0109	23.2

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Ozone (ppb-hr)
Stanislaus NF	Sonora Pass	23-Jun	7-Jul	0.0102	0.0089	29.8
Stanislaus NF	Sonora Pass	7-Jul	21-Jul	0.0104	0.0106	32.7
Stanislaus NF	Sonora Pass	21-Jul	4-Aug	0.0102	0.0090	29.9
Stanislaus NF	Sonora Pass	4-Aug	18-Aug	0.0067	0.0073	21.8
Stanislaus NF	Sonora Pass	18-Aug	2-Sep	0.0066	0.0074	21.8
Stanislaus NF	Sonora Pass	2-Sep	16-Sep	0.0115	0.0114	35.7
Stanislaus NF	Sonora Pass	16-Sep	29-Sep	0.0086	0.0086	26.8
Tahoe NF	North Yuba/Marysville	13-May	27-May	0.0139	0.0148	44.7
Tahoe NF	North Yuba/Marysville	27-May	9-Jun	0.0125	0.0117	37.7
Tahoe NF	North Yuba/Marysville	9-Jun	24-Jun	0.0127	0.0133	40.5
Tahoe NF	North Yuba/Marysville	24-Jun	8-Jul	0.0126	0.0120	38.4
Tahoe NF	North Yuba/Marysville	8-Jul	22-Jul	0.0153	0.0015	26.2
Tahoe NF	North Yuba/Marysville	22-Jul	5-Aug	0.0146	0.0159	47.5
Tahoe NF	North Yuba/Marysville	5-Aug	19-Aug	0.0127	0.0126	39.4
Tahoe NF	North Yuba/Marysville	19-Aug	2-Sep	0.0145	0.0139	44.3
Tahoe NF	North Yuba/Marysville	2-Sep	16-Sep	0.0163	0.0170	51.9
Tahoe NF	North Yuba/Marysville	16-Sep	30-Sep	0.0149	0.0148	46.3
Tahoe NF	Downieville	13-May	27-May	0.0112	0.0117	35.7
Tahoe NF	Downieville	27-May	9-Jun	0.0094	0.0075	26.3
Tahoe NF	Downieville	9-Jun	24-Jun	0.0114	0.0123	36.9
Tahoe NF	Downieville	24-Jun	8-Jul	0.0101	0.0106	32.3
Tahoe NF	Downieville	8-Jul	22-Jul	0.0086	0.0118	31.8
Tahoe NF	Downieville	22-Jul	5-Aug	0.0116	0.0126	37.7
Tahoe NF	Downieville	5-Aug	19-Aug	0.0110	0.0127	36.9
Tahoe NF	Downieville	19-Aug	2-Sep	0.0126	0.0134	40.5
Tahoe NF	Downieville	2-Sep	16-Sep	0.0149	0.0136	44.4
Tahoe NF	Downieville	16-Sep	30-Sep	0.0132	0.0124	39.9
Tahoe NF	Yuba Pass	9-Jun	24-Jun	0.0154	0.0158	48.6
Tahoe NF	Yuba Pass	24-Jun	8-Jul	0.0213	0.0167	59.2
Tahoe NF	Yuba Pass	8-Jul	22-Jul	0.0162	0.0174	52.4
Tahoe NF	Yuba Pass	22-Jul	5-Aug	0.0159	0.0158	49.4
Tahoe NF	Yuba Pass	5-Aug	19-Aug	0.0133	0.0137	42.1
Tahoe NF	Yuba Pass	19-Aug	2-Sep	0.0161	0.0164	50.7
Tahoe NF	Yuba Pass	2-Sep	16-Sep	0.0147	0.0161	48.0
Tahoe NF	Yuba Pass	16-Sep	30-Sep	0.0160	0.0164	50.5
Tahoe NF	Nevada City	13-May	27-May	0.0164	0.0162	50.8
Tahoe NF	Nevada City	27-May	9-Jun	0.0138	0.0134	42.4
Tahoe NF	Nevada City	9-Jun	24-Jun	0.0114	0.0115	35.7
Tahoe NF	Nevada City	24-Jun	8-Jul	0.0142	0.0142	44.3
Tahoe NF	Nevada City	8-Jul	22-Jul	0.0176	0.0177	55.0
Tahoe NF	Nevada City	22-Jul	4-Aug	0.0168	0.0168	52.4
Tahoe NF	Nevada City	19-Aug	2-Sep	0.0193	0.0178	57.8
Tahoe NF	Nevada City	2-Sep	16-Sep	0.0201	0.0207	63.6
Tahoe NF	Nevada City	16-Sep	29-Sep	0.0171	0.0174	53.8
Tahoe NF	White Cloud	13-May	27-May	0.0162	0.0163	50.7
Tahoe NF	White Cloud	27-May	9-Jun	0.0142	0.0143	44.4
Tahoe NF	White Cloud	9-Jun	24-Jun	0.0135	0.0167	47.1
Tahoe NF	White Cloud	24-Jun	8-Jul	0.0159	0.0135	45.8
Tahoe NF	White Cloud	8-Jul	22-Jul	0.0222	0.0201	65.9

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Ozone (ppb-hr)
Tahoe NF	White Cloud	22-Jul	4-Aug	0.0182	0.0171	55.0
Tahoe NF	White Cloud	4-Aug	19-Aug	0.0165	0.0157	50.2
Tahoe NF	White Cloud	19-Aug	1-Sep	0.0182	0.0189	57.8
Tahoe NF	White Cloud	1-Sep	15-Sep	0.0198	0.0200	62.0
Tahoe NF	White Cloud	15-Sep	29-Sep	0.0185	0.0184	57.5
Tahoe NF	Cisco Grove/Kelly Lake	9-Jun	24-Jun	0.0122	0.0141	41.0
Tahoe NF	Cisco Grove/Kelly Lake	24-Jun	8-Jul	0.0137	0.0145	44.0
Tahoe NF	Cisco Grove/Kelly Lake	8-Jul	22-Jul	0.0149	0.0151	46.8
Tahoe NF	Cisco Grove/Kelly Lake	22-Jul	5-Aug	0.0144	0.0146	45.2
Tahoe NF	Cisco Grove/Kelly Lake	5-Aug	19-Aug	0.0125	0.0139	41.2
Tahoe NF	Cisco Grove/Kelly Lake	19-Aug	2-Sep	0.0147	0.0145	45.5
Tahoe NF	Cisco Grove/Kelly Lake	2-Sep	16-Sep	0.0163	0.0154	49.4
Tahoe NF	Cisco Grove/Kelly Lake	16-Sep	30-Sep	0.0146	0.0141	44.7
Tahoe NF	Serene	9-Jun	24-Jun	0.0179	0.0157	52.4
Tahoe NF	Serene	24-Jun	8-Jul	0.0184	0.0332	80.4
Tahoe NF	Serene	8-Jul	22-Jul	0.0190	0.0213	62.8
Tahoe NF	Serene	22-Jul	5-Aug	0.0191	0.0175	57.1
Tahoe NF	Serene	5-Aug	19-Aug	0.0153	0.0190	53.5
Tahoe NF	Serene	19-Aug	2-Sep	0.0253	0.0192	69.4
Tahoe NF	Serene	2-Sep	16-Sep	0.0184	0.0184	57.4
Tahoe NF	Serene	16-Sep	30-Sep	0.0183	0.0193	58.6
Tahoe NF	Hobart	13-May	27-May	0.0109	0.0109	34.0
Tahoe NF	Hobart	27-May	9-Jun	0.0110	0.0108	34.0
Tahoe NF	Hobart	9-Jun	24-Jun	0.0117	0.0129	38.4
Tahoe NF	Hobart	24-Jun	8-Jul	0.0124	0.0095	34.1
Tahoe NF	Hobart	8-Jul	22-Jul	0.0122	0.0119	37.6
Tahoe NF	Hobart	22-Jul	5-Aug	0.0112	0.0105	33.8
Tahoe NF	Hobart	5-Aug	19-Aug	0.0115	0.0104	34.1
Tahoe NF	Hobart	19-Aug	2-Sep	0.0114	0.0116	35.9
Tahoe NF	Hobart	2-Sep	16-Sep	0.0119	0.0121	37.4
Tahoe NF	Hobart	16-Sep	30-Sep	0.0124	0.0134	40.2
Tahoe NF	Foresthill Road	13-May	27-May	0.0161	0.0184	53.8
Tahoe NF	Foresthill Road	27-May	10-Jun	0.0148	0.0135	44.1
Tahoe NF	Foresthill Road	10-Jun	24-Jun	0.0171	0.0203	58.3
Tahoe NF	Foresthill Road	24-Jun	8-Jul	0.0163	0.0165	51.1
Tahoe NF	Foresthill Road	8-Jul	22-Jul	0.0208	0.0192	62.4
Tahoe NF	Foresthill Road	22-Jul	4-Aug	0.0174	0.0209	59.7
Tahoe NF	Foresthill Road	4-Aug	19-Aug	0.0168	0.0155	50.4
Tahoe NF	Foresthill Road	19-Aug	2-Sep	0.0394	0.0202	92.9
Tahoe NF	Foresthill Road	2-Sep	16-Sep	0.0246	0.0219	72.5
Tahoe NF	Foresthill Road	16-Sep	29-Sep	0.0166	0.0175	53.2
Tahoe NF	Foresthill Seed Orchard	13-May	27-May	0.0132	0.0173	47.5
Tahoe NF	Foresthill Seed Orchard	27-May	10-Jun	0.0157	0.0136	45.7
Tahoe NF	Foresthill Seed Orchard	10-Jun	24-Jun	0.0181	0.0183	56.7
Tahoe NF	Foresthill Seed Orchard	24-Jun	8-Jul	0.0160	0.0166	50.8
Tahoe NF	Foresthill Seed Orchard	8-Jul	22-Jul	0.0213	0.0201	64.5
Tahoe NF	Foresthill Seed Orchard	22-Jul	4-Aug	0.0196	0.0191	60.3
Tahoe NF	Foresthill Seed Orchard	4-Aug	19-Aug	0.0171	0.0160	51.6
Tahoe NF	Foresthill Seed Orchard	19-Aug	2-Sep	0.0207	0.0204	64.1

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Ozone (ppb-hr)
Tahoe NF	Foresthill Seed Orchard	2-Sep	16-Sep	0.0032	0.0200	36.2
Tahoe NF	Foresthill Seed Orchard	16-Sep	29-Sep	0.0193	0.0177	57.7
Sequoia NP	Three Pole Corner	26-May	9-Jun	0.0168	0.0184	54.9
Sequoia NP	Three Pole Corner	9-Jun	24-Jun	0.0266	0.0266	82.9
Sequoia NP	Three Pole Corner	24-Jun	8-Jul	0.0268	0.0276	84.8
Sequoia NP	Three Pole Corner	8-Jul	21-Jul	0.0212	0.0219	67.2
Sequoia NP	Three Pole Corner	21-Jul	3-Aug	0.0254	0.0251	78.7
Sequoia NP	Three Pole Corner	3-Aug	17-Aug	0.0193	0.0192	60.0
Sequoia NP	Three Pole Corner	17-Aug	1-Sep	0.0232	0.0237	73.1
Sequoia NP	Three Pole Corner	1-Sep	14-Sep	0.0249	0.0241	76.4
Sequoia NP	Three Pole Corner	14-Sep	30-Sep	0.0240	0.0229	73.1
Sequoia NP	Three Pole Corner	30-Sep	14-Oct	0.0203	0.0203	63.3
Sequoia NP	Little Baldy Saddle	13-May	26-May	0.0175	0.0172	54.1
Sequoia NP	Little Baldy Saddle	26-May	9-Jun	0.0165	0.0159	50.5
Sequoia NP	Little Baldy Saddle	9-Jun	24-Jun	0.0252	0.0252	78.6
Sequoia NP	Little Baldy Saddle	24-Jun	7-Jul	0.0228	0.0228	71.1
Sequoia NP	Little Baldy Saddle	7-Jul	21-Jul	0.0211	0.0202	64.4
Sequoia NP	Little Baldy Saddle	21-Jul	4-Aug	0.0224	0.0229	70.6
Sequoia NP	Little Baldy Saddle	4-Aug	18-Aug	0.0174	0.0174	54.3
Sequoia NP	Little Baldy Saddle	18-Aug	2-Sep	0.0212	0.0219	67.2
Sequoia NP	Little Baldy Saddle	2-Sep	15-Sep	0.0203	0.0209	64.2
Sequoia NP	Little Baldy Saddle	15-Sep	29-Sep	0.0192	0.0197	60.6
Sequoia NP	Little Baldy Saddle	29-Sep	13-Oct	0.0181	0.0181	56.4
Sequoia NP	Pinehurst Work Center	12-May	26-May	0.0174	0.0170	53.6
Sequoia NP	Pinehurst Work Center	26-May	9-Jun	0.0164	0.0166	51.4
Sequoia NP	Pinehurst Work Center	9-Jun	23-Jun	0.0259	0.0278	83.7
Sequoia NP	Pinehurst Work Center	24-Jun	7-Jul	0.0231	0.0241	73.6
Sequoia NP	Pinehurst Work Center	7-Jul	21-Jul	0.0261	0.0238	77.8
Sequoia NP	Pinehurst Work Center	21-Jul	4-Aug	0.0187	0.0190	58.8
Sequoia NP	Pinehurst Work Center	4-Aug	19-Aug	0.0215	0.0202	65.0
Sequoia NP	Pinehurst Work Center	19-Aug	1-Sep	0.0229	0.0239	73.0
Sequoia NP	Pinehurst Work Center	2-Sep	16-Sep	0.0289	0.0266	86.5
Sequoia NP	Pinehurst Work Center	16-Sep	30-Sep	0.0218	0.0222	68.6
Sequoia NP	Swale Work Center	27-May	9-Jun	0.0142	0.0132	42.7
Sequoia NP	Swale Work Center	9-Jun	23-Jun	0.0231	0.0225	71.1
Sequoia NP	Swale Work Center	26-Jun	7-Jul	0.0280	0.0260	84.2
Sequoia NP	Swale Work Center	7-Jul	21-Jul	0.0196	0.0191	60.3
Sequoia NP	Swale Work Center	22-Jul	4-Aug	0.0197	0.0175	58.0
Sequoia NP	Swale Work Center	4-Aug	19-Aug	0.0166	0.0167	51.9
Sequoia NP	Swale Work Center	19-Aug	1-Sep	0.0191	0.0195	60.2
Sequoia NP	Swale Work Center	1-Sep	16-Sep	0.0208	0.0216	66.1
Sequoia NP	Swale Work Center	16-Sep	30-Sep	0.0170	0.0168	52.7

Table A-2. Ambient ozone sites, beginning and ending exposure dates, oxidation rates and corresponding estimate ambient ozone for several additional sites in Sequoia National Park that were jointly funded with another project. These sites had 4 samplers per time period rather than 2 samplers per time period used for this study, and were located within a smaller area relative to other sampler sites used for this study.

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Sampler 3 Oxidation Rate	Sampler 4 Oxidation Rate	Ozone (ppb-hr)
Sequoia NP	Lower Kaweah	12-May	27-May	0.0179	0.0170	0.0171	0.0173	54.0
Sequoia NP	Lower Kaweah	27-May	9-Jun	0.0168	0.0167	0.0156	0.0151	50.0
Sequoia NP	Lower Kaweah	9-Jun	24-Jun	0.0252	0.0247	0.0249	0.0239	76.9
Sequoia NP	Lower Kaweah	24-Jun	8-Jul	0.0244	0.0241	0.0229	0.0251	75.2
Sequoia NP	Lower Kaweah	8-Jul	21-Jul	0.0208	0.0204	0.0207	0.0203	64.1
Sequoia NP	Lower Kaweah	21-Jul	3-Aug	0.0203	0.0214	0.0201	0.0206	64.2
Sequoia NP	Lower Kaweah	3-Aug	18-Aug	0.0142	0.0144	0.0137	0.0146	44.4
Sequoia NP	Lower Kaweah	18-Aug	1-Sep	0.0200	0.0201	0.0196	0.0188	61.2
Sequoia NP	Lower Kaweah	1-Sep	14-Sep	0.0196	0.0201	0.0187	0.0197	60.9
Sequoia NP	Lower Kaweah	14-Sep	29-Sep	0.0179	0.0176	0.0180	0.0175	55.3
Sequoia NP	Lower Kaweah	29-Sep	14-Oct	0.0175	0.0173	0.0166	0.0180	54.1
Sequoia NP	Crystal Cave	12-May	27-May	0.0161	0.0158	0.0162	0.0158	49.8
Sequoia NP	Crystal Cave	27-May	9-Jun	0.0140	0.0128	0.0141	0.0135	42.4
Sequoia NP	Crystal Cave	9-Jun	24-Jun	0.0151	0.0142	0.0136	0.0155	45.5
Sequoia NP	Crystal Cave	8-Jul	21-Jul	0.0168	0.0176	0.0174	0.0174	53.9
Sequoia NP	Crystal Cave	21-Jul	4-Aug	0.0205	0.0206	0.0216	0.0218	65.9
Sequoia NP	Crystal Cave	4-Aug	17-Aug	0.0142	0.0149	0.0146	0.0141	45.1
Sequoia NP	Crystal Cave	17-Aug	1-Sep	0.0165	0.0172	0.0178	0.0171	53.5
Sequoia NP	Crystal Cave	1-Sep	14-Sep	0.0194	0.0190	0.0191	0.0199	60.3
Sequoia NP	Crystal Cave	14-Sep	30-Sep	0.0174	0.0175	0.0173	0.0174	54.3
Sequoia NP	Crystal Cave	30-Sep	14-Oct	0.0163	0.0162	0.0159	0.0161	50.3
Sequoia NP	Stony Creek	13-May	26-May	0.0135	0.0130	0.0136	0.0134	41.7
Sequoia NP	Stony Creek	26-May	9-Jun	0.0125	0.0118	0.0131	0.0132	39.4
Sequoia NP	Stony Creek	9-Jun	24-Jun	0.0177	0.0186	0.0181	0.0183	56.7
Sequoia NP	Stony Creek	24-Jun	7-Jul	0.0173	0.0180	0.0178	0.0174	55.0
Sequoia NP	Stony Creek	7-Jul	21-Jul	0.0142	0.0148	0.0145	0.0147	45.4
Sequoia NP	Stony Creek	21-Jul	4-Aug	0.0170	0.0165	0.0166	0.0162	51.7
Sequoia NP	Stony Creek	4-Aug	18-Aug	0.0135	0.0132	0.0131	0.0137	41.7
Sequoia NP	Stony Creek	18-Aug	2-Sep	0.0155	0.0165	0.0161	0.0159	49.9

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Sampler 3 Oxidation Rate	Sampler 4 Oxidation Rate	Ozone (ppb-hr)
Sequoia NP	Stony Creek	2-Sep	15-Sep	NA	0.0196	0.0184	0.0192	59.4
Sequoia NP	Stony Creek	15-Sep	29-Sep	0.0136	0.0150	0.0138	0.0141	44.0
Sequoia NP	Stony Creek	29-Sep	13-Oct	0.0153	0.0150	0.0153	0.0155	47.6
Sequoia NP	Wolverton	12-May	26-May	0.0124	0.0139	0.0136	0.0138	41.9
Sequoia NP	Wolverton	26-May	9-Jun	0.0127	0.0133	0.0116	0.0103	37.3
Sequoia NP	Wolverton	9-Jun	24-Jun	0.0190	0.0190	0.0186	0.0190	58.9
Sequoia NP	Wolverton	24-Jun	8-Jul	0.0140	0.0138	0.0143	0.0139	43.7
Sequoia NP	Wolverton	8-Jul	21-Jul	0.0123	0.0125	0.0126	0.0123	38.7
Sequoia NP	Wolverton	21-Jul	3-Aug	0.0134	0.0136	0.0142	0.0139	43.0
Sequoia NP	Wolverton	3-Aug	18-Aug	0.0114	0.0110	0.0112	0.0119	35.5
Sequoia NP	Wolverton	18-Aug	1-Sep	0.0134	0.0130	0.0132	0.0135	41.4
Sequoia NP	Wolverton	1-Sep	14-Sep	0.0144	0.0138	0.0140	0.0144	44.1
Sequoia NP	Wolverton	14-Sep	29-Sep	0.0104	0.0103	0.0103	0.0119	33.4
Sequoia NP	Wolverton	29-Sep	13-Oct	0.0111	0.0114	0.0113	0.0115	35.3
Sequoia NP	Ash Mountain	12-May	26-May	0.0167	0.0164	0.0168	0.0176	52.6
Sequoia NP	Ash Mountain	26-May	9-Jun	0.0176	0.0167	0.0171	0.0169	53.2
Sequoia NP	Ash Mountain	9-Jun	24-Jun	0.0241	0.0245	0.0233	0.0240	74.8
Sequoia NP	Ash Mountain	24-Jun	8-Jul	0.0238	0.0241	0.0211	0.0233	71.9
Sequoia NP	Ash Mountain	8-Jul	21-Jul	0.0189	0.0202	0.0207	0.0207	62.7
Sequoia NP	Ash Mountain	21-Jul	3-Aug	0.0211	0.0205	0.0220	0.0235	67.9
Sequoia NP	Ash Mountain	3-Aug	17-Aug	0.0200	0.0195	0.0190	0.0191	60.5
Sequoia NP	Ash Mountain	17-Aug	1-Sep	0.0226	0.0226	0.0224	0.0221	69.9
Sequoia NP	Ash Mountain	1-Sep	14-Sep	0.0229	0.0224	0.0226	0.0226	70.5
Sequoia NP	Ash Mountain	14-Sep	30-Sep	0.0216	0.0207	0.0211	0.0228	67.2
Sequoia NP	Ash Mountain	30-Sep	14-Oct	0.0191	0.0174	0.0185	0.0178	56.7
Sequoia NP	Marble Fork	12-May	26-May	0.0141	0.0136	0.0125	0.0136	41.9
Sequoia NP	Marble Fork	26-May	9-Jun	0.0130	0.0122	0.0123	0.0125	39.0
Sequoia NP	Marble Fork	9-Jun	24-Jun	0.0189	0.0186	0.0182	0.0184	57.8
Sequoia NP	Marble Fork	24-Jun	7-Jul	0.0180	0.0179	0.0171	0.0179	55.3
Sequoia NP	Marble Fork	7-Jul	21-Jul	0.0132	0.0141	0.0136	0.0138	42.6
Sequoia NP	Marble Fork	21-Jul	4-Aug	0.0169	0.0167	0.0171	0.0172	52.9
Sequoia NP	Marble Fork	4-Aug	18-Aug	0.0125	0.0129	0.0126	0.0128	39.6
Sequoia NP	Marble Fork	18-Aug	2-Sep	0.0164	0.0161	0.0160	0.0168	50.9
Sequoia NP	Marble Fork	2-Sep	15-Sep	0.0154	0.0158	0.0154	0.0155	48.4
Sequoia NP	Marble Fork	15-Sep	29-Sep	0.0122	0.0125	0.0125	0.0123	38.6
Sequoia NP	Marble Fork	29-Sep	13-Oct	0.0124	0.0130	0.0126	0.0130	39.8
Sequoia NP	Huckleberry Meadow	13-May	27-May	0.0156	0.0161	0.0160	0.0162	49.8
Sequoia NP	Huckleberry Meadow	27-May	9-Jun	0.0142	0.0139	0.0146	0.0168	46.4

Forest	Site Name	Date On	Date Off	Sampler 1 Oxidation Rate	Sampler 2 Oxidation Rate	Sampler 3 Oxidation Rate	Sampler 4 Oxidation Rate	Ozone (ppb-hr)
Sequoia NP	Huckleberry Meadow	9-Jun	24-Jun	0.0228	0.0225	0.0226	0.0228	70.7
Sequoia NP	Huckleberry Meadow	24-Jun	8-Jul	0.0232	0.0224	0.0225	0.0231	71.1
Sequoia NP	Huckleberry Meadow	8-Jul	21-Jul	0.0183	0.0184	0.0193	0.0189	58.4
Sequoia NP	Huckleberry Meadow	21-Jul	3-Aug	0.0191	0.0189	0.0186	0.0183	58.4
Sequoia NP	Huckleberry Meadow	3-Aug	18-Aug	NA	0.0155	0.0163	0.0145	48.1
Sequoia NP	Huckleberry Meadow	18-Aug	1-Sep	0.0198	0.0187	0.0210	0.0186	60.9
Sequoia NP	Huckleberry Meadow	1-Sep	14-Sep	0.0182	0.0198	0.0204	0.0200	61.1
Sequoia NP	Huckleberry Meadow	14-Sep	30-Sep	0.0178	0.0193	0.0173	0.0174	56.0
Sequoia NP	Huckleberry Meadow	30-Sep	13-Oct	0.0181	0.0178	0.0183	0.0173	55.7