Sonoma Technology, Inc.
Air Quality Research and Innovative Solutions

CONTRIBUTORS TO SACRAMENTO COUNTY WOOD SMOKE PRIMARY $PM_{2.5}$

Final Report
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1. INTRODUCTION

On October 25, 2007, the Sacramento Metropolitan Air Quality Management District (SMAQMD) adopted Rule 421, Mandatory Episodic Curtailment of Wood and Other Solid Fuel Burning. The rule established a burning curtailment program with three restriction levels that are communicated to the public before a possible curtailment. The restriction level depends on the "next-day" 24-hr average $PM_{2.5}$ concentration[1] forecast for Sacramento County, issued every day by 11 a.m.[2] Forecasted concentrations that trigger burning curtailment for each restriction level follow:

- $PM_{2.5}$ forecast >25 μg/m^3 to ≤35 μg/m^3: Voluntary curtailment during which burning is discouraged.
- $PM_{2.5}$ forecast >35 μg/m^3 to ≤40 μg/m^3: Stage 1 mandatory curtailment, during which no burning is allowed except in U.S. Environmental Protection Agency (EPA)-certified woodstoves and inserts or pellet stoves.
- $PM_{2.5}$ forecast >40 μg/m^3: Stage 2 mandatory curtailment during which no burning is allowed in any device.

Rule 421 is in effect each "winter" from the beginning of November through the end of February. The rule has been in place for two winters. However, for the first winter of the program, the rule was in effect from December 1, 2007, through the end of February 2008.

SMAQMD asked Sonoma Technology, Inc. (STI) to provide information that can be used to consider whether any changes to Rule 421 would help Sacramento County comply with National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$. This work was divided into two phases. For Phase I, STI addressed the following questions:

- What is the effectiveness of the burning curtailment program toward meeting the NAAQS?
- Was the 2008/2009 wood-burning season representative of normal $PM_{2.5}$ concentrations?
- What should the no-burn threshold be to help reduce $PM_{2.5}$ below NAAQS?
- Should no-burn days be called on the day prior to forecasted high-$PM_{2.5}$ concentration days (days expected to exceed NAAQS) to help lower pollution during $PM_{2.5}$ episodes?

Phase I results are presented in MacDonald et al. (2009).

For Phase II, STI investigated the contribution to wood smoke primary $PM_{2.5}$ at several receptor sites from residential wood smoke emissions originating in urban Sacramento County, rural Sacramento County, Sacramento County as a whole, and surrounding counties. To estimate contributions, STI performed two independent analyses: (1) modeling with the Fifth-Generation NCAR/Penn State Mesoscale Model (MM5) and the Comprehensive Air Quality Model with extensions (CAMx) (called MM5/CAMx in this report), and (2) trajectory modeling using the

[1] $PM_{2.5}$ includes particles in the air that are less then 2.5 microns in diameter.
[2] On a few days, the restriction level was changed on the basis of a "same-day" forecast.

Transported Emissions Assessment Kit (TEAK). Using two independent methods provided a greater certainty in the findings compared to findings based on a single method. Details of each method can be found in Section 3 of this report.

Both MM5/CAMx and TEAK modeling methods rely on estimates of residential wood smoke emissions. Gridded residential wood smoke emissions data were developed from 2009 county-level average winter day emissions data provided by the SMAQMD. The original emissions data provided by SMAQMD were based on the California Air Resources Board (ARB) emissions inventory, version 1.06, which uses a 2002 base year. After these modeling simulations were completed, two sets of updated residential wood smoke emissions data for selected counties were provided by the SMAQMD in the form of county-level scaling factor adjustments to the original inventory used in the modeling. These updated emissions were used to reflect possible changes to the emission inventory by the California Air Resources Board. Because the modeling in this analysis deals only with inert, primary $PM_{2.5}$ emissions, it can be assumed that the absolute wood smoke contribution from a source region is linearly proportional to the emission rate in that source region. Therefore, these scaling factor adjustments were applied to the predicted daily average residential wood smoke $PM_{2.5}$ contributions. The findings presented in the main body and in Appendix A of this report are based on the emission scaling factors called "Current Draft Inventory", which are shown in **Table 1-1**. The contribution results presented in Appendices B-D of this report use the scaling factors called "Consistent Inventory Methodology", which are shown in **Table 1-2**. The original emissions, current draft inventory emissions, and consistent inventory methodology emissions are shown in **Figure 1-1**.

Table 1-1. Residential wood smoke emission inventory scaling factors called the "Current Draft Inventory".

County	Scale Factor
Sacramento	1.22
El Dorado	0.26
Placer	0.75
Yolo	0.85
Solano	0.75

Table 1-2. Residential wood smoke emission inventory scaling factors called the "Consistent Inventory Methodology".

County	Scale Factor
Sacramento	1.22
El Dorado	0.26
Placer	0.85
Yolo	2.71
Solano	2.54

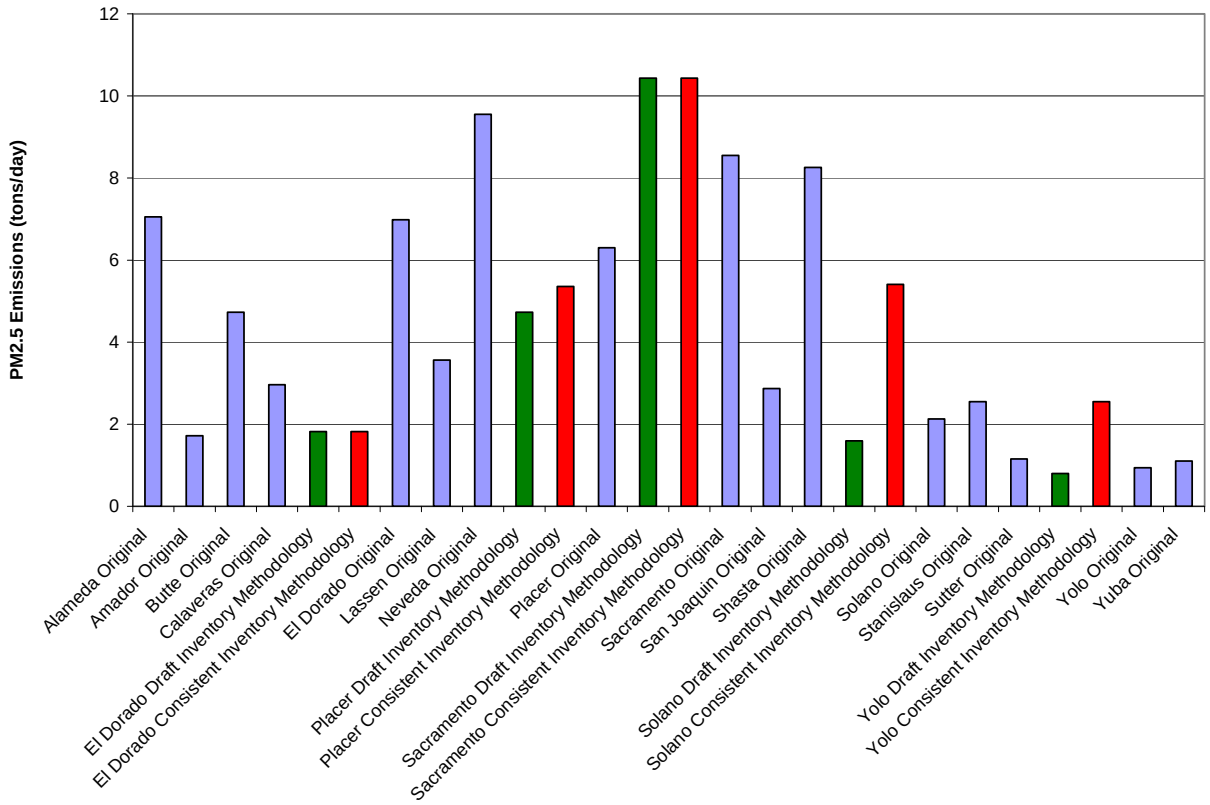

Figure 1-1. The original emissions, current draft inventory emissions, and consistent inventory methodology emissions.

The results presented in this report focus on the contributions to wood smoke primary $PM_{2.5}$ concentrations[3] at Del Paso Manor, Folsom, and Bruceville from residential wood smoke only. Appendix A contains source contribution information for other receptor sites including Davis, Roseville, and Rancho Seco. Del Paso Manor was selected because that site has the greatest number of $PM_{2.5}$ exceedances in Sacramento County. Folsom and Bruceville were selected because of concerns about significant transport of $PM_{2.5}$ to these sites from surrounding counties and rural Sacramento County. In addition, although Folsom and Bruceville do not have Federal Reference Monitors to measure $PM_{2.5}$, they do have continuous Beta Attenuation Monitors (BAMS) to measure $PM_{2.5}$. The daily 24-hr BAM data show that the Folsom monitoring site is just below the NAAQS for $PM_{2.5}$ and Bruceville is just above the NAAQS for $PM_{2.5}$. Therefore, implementing no-burn days in these areas may reduce localized poor air quality and improve health.

[3] Primary $PM_{2.5}$ are directly emitted particles. Secondary $PM_{2.5}$ are from gaseous emissions that then react to form particles. Total $PM_{2.5}$ mass measured at a site includes both secondary and primary $PM_{2.5}$.

2. KEY FINDINGS

Sections 2.1 through 2.3 present key findings regarding the contribution of primary $PM_{2.5}$ from residential wood smoke emissions in surrounding areas to primary $PM_{2.5}$ concentrations measured at the Del Paso Manor, Folsom, and Bruceville monitoring sites. All findings pertain to days on which Sacramento County exceeded the NAAQS for daily average $PM_{2.5}$ concentrations for the winters (November through February) of 2000/2001,[4] 2007/2008, 2008/2009. Appendix E contains the 24-hr average $PM_{2.5}$ concentrations for each day analyzed. Contribution ranges reflecting the results from both analysis methods are reported in this section, except for results for sub-county source areas (e.g. rural Sacramento), which are based on the MM5/CAMx method only. Detailed answers to specific questions regarding contributions to these receptor sites are presented in Section 4. Section 2.4 presents key findings derived from additional information contained in Appendices B-D.

It should be noted that all reasonable efforts were made to provide accurate and representative findings regarding contribution. In addition, a review of emission patterns and meteorological conditions that occurred during high $PM_{2.5}$ episodes in the Sacramento Valley indicates that the findings in this report are conceptually reasonable. However, the findings should be viewed as rough estimates due to inherent uncertainties associated with any modeling analyses. Uncertainties arise from the fact that (1) modeled wind fields are not always representative of the observed localized wind fields, (2) model-predicted $PM_{2.5}$ contributions are subject to other biases and errors inherent in the meteorological model used to produce data required by the air quality model, (3) mixing heights, which are an important factor in controlling the contribution amounts presented in this report, were based on average hourly winter $PM_{2.5}$ episode data, and (4) the TEAK method did not include deposition or dispersion.

It should also be noted that the total $PM_{2.5}$ mass measured at monitoring sites includes both primary and secondary $PM_{2.5}$. Prior analysis showed that up to 40% of the total $PM_{2.5}$ mass was primary $PM_{2.5}$ from wood smoke emissions (MacDonald et al., 2009). In addition, gases emitted from residential wood burning contribute to secondary $PM_{2.5}$; however, this contribution is difficult to quantify. Therefore, the contributions reported in this document account for roughly half the total $PM_{2.5}$ measured at a monitoring site. The remaining $PM_{2.5}$ mass comes from a variety of sources such as automobiles, trucks, agriculture, and industry.

In summary, Del Paso Manor's primary $PM_{2.5}$ from wood smoke is mostly attributable to wood smoke sources in urban Sacramento County. Folsom's primary $PM_{2.5}$ from wood smoke is mostly attributable to wood smoke sources in Sacramento County, Placer County, and El Dorado County. Bruceville's primary $PM_{2.5}$ from wood smoke is mostly attributable to wood smoke sources in urban and rural Sacramento County. In addition, the results of the two methods were generally consistent; however, the TEAK method showed higher contributions from counties outside Sacramento County than did the MM5/CAMx method. This difference was expected because MM5/CAMx included deposition and dispersion, whereas the TEAK method did not.

[4] Five days included in the December 15, 2000 through January 9, 2001, CRPAQS study period did not exceed NAAQS, but were included because they were part of multi-day high $PM_{2.5}$ episodes.

2.1 DEL PASO MANOR

Key findings regarding the contribution of primary $PM_{2.5}$ generated from residential wood smoke emissions from surrounding areas to total wood smoke primary $PM_{2.5}$ at the Del Paso Manor monitor site follow. Contribution ranges reflect the results from both analysis methods. The average refers to the average results from all days analyzed.

- Results from the two different methods show that 63–84% of the wood smoke primary $PM_{2.5}$ at Del Paso Manor is attributable to wood smoke emissions from Sacramento County on average. *Therefore, no-burn days in Sacramento County alone are an effective way to reduce $PM_{2.5}$ at Del Paso Manor.*
- Results from the two different methods show that no other single county contributes more than 3–8% to the primary $PM_{2.5}$ at Del Paso Manor. *Therefore, implementing no-burn days in a single county outside Sacramento will have, at most, a modest effect on reducing $PM_{2.5}$ at Del Paso Manor.*
- Results from the two different methods show that 2–10% of the wood smoke primary $PM_{2.5}$ at Del Paso Manor is attributable to wood smoke emissions from Placer, El Dorado, Yolo, and Solano Counties collectively on average. *Therefore, implementing no-burn days in these four counties on days when Sacramento has high $PM_{2.5}$ will have, at most, a modest effect on reducing $PM_{2.5}$ at Del Paso Manor.*
- Results from the MM5/CAMx method show that 3% of the wood smoke primary $PM_{2.5}$ at Del Paso Manor is attributable to wood smoke emissions from rural Sacramento County on average. *Therefore, having no-burn days in rural Sacramento will have little effect on reducing $PM_{2.5}$ at Del Paso Manor. However, implementing no-burn days in rural areas on days conducive to high $PM_{2.5}$ may reduce localized areas of poor air quality that could have negative health impacts on rural Sacramento residents.*

2.2 FOLSOM

Key findings regarding the contribution of primary $PM_{2.5}$ from residential wood smoke emissions from surrounding areas to primary $PM_{2.5}$ concentrations at the Folsom monitor site follow. Contribution ranges reflect the results from both analysis methods.

- Results from the two different methods show that 39–57% of the wood smoke primary $PM_{2.5}$ at Folsom is attributable to wood smoke emissions from Sacramento County on average. *Therefore, no-burn days in Sacramento County alone are an effective way to reduce $PM_{2.5}$ at Folsom.*
- Results from the two different methods show that 19-30% of the wood smoke primary $PM_{2.5}$ at Folsom is attributable to wood smoke emissions from Placer, El Dorado, Yolo, and Solano counties collectively; the majority of the contribution is from Placer and El Dorado counties on average. *Therefore, implementing no-burn days in Placer and El Dorado counties on days when Sacramento has high $PM_{2.5}$ should have a significant effect on reducing $PM_{2.5}$ at Folsom.*
- Results from the MM5/CAMx method show that about 2% of the wood smoke primary $PM_{2.5}$ at Folsom is attributable to wood smoke emissions from rural Sacramento County

on average. *Therefore, no-burn days in rural Sacramento will have little effect on reducing $PM_{2.5}$ at Folsom. However, no-burn days in rural areas on days conducive to high $PM_{2.5}$ may reduce localized areas of poor air quality that could have negative health impacts on rural Sacramento residents.*

2.3 BRUCEVILLE

Key findings regarding the contribution of primary $PM_{2.5}$ generated from residential wood smoke emissions from surrounding areas to primary $PM_{2.5}$ concentrations at the Bruceville monitor site follow. Contribution ranges reflect the results from both analysis methods.

- Results from the two different methods show that 53–55% of the wood smoke primary $PM_{2.5}$ at Bruceville is attributable to wood smoke emissions from Sacramento County on average. *Therefore, no-burn days in Sacramento County alone are an effective way to reduce $PM_{2.5}$ at Bruceville.*
- Results from the two different methods show that no other single county contributes more than 5–10% to the wood smoke primary $PM_{2.5}$ at Bruceville on average. *Therefore, implementing no-burn days in a single county outside Sacramento will have little effect on reducing $PM_{2.5}$ at Bruceville.*
- Results from the two different methods show that 5–9% of the wood smoke primary $PM_{2.5}$ at Bruceville is attributable to wood smoke emissions from Placer, El Dorado, Yolo, and Solano Counties collectively, on average. *Therefore, implementing no-burn days in these four counties on days when Sacramento has high $PM_{2.5}$ will have, at most, a modest effect on reducing $PM_{2.5}$ at Bruceville.*
- Results from the MM5/CAMx method show that about 15% of the wood smoke primary $PM_{2.5}$ at Bruceville is attributable to wood smoke emissions from rural Sacramento County on average. *Therefore, having no-burn days in rural Sacramento should have a substantial effect on reducing $PM_{2.5}$ at Bruceville.*

2.4 SUMMARY OF FINDINGS DETAILED IN APPENDICES B THROUGH D

Additional information about wood smoke contributions is contained in Appendices B-D. A summary of that information and significant findings is provided below.

- **Appendix B** describes the contribution results in the form of data plots for the Del Paso Manor, Folsom, Bruceville, Davis, Roseville, and Rancho Seco receptors using the "Consistent Inventory Methodology" to derive the emissions. In general, the contribution results using the "Consistent Inventory Methodology" scaling factors for the emissions data are about 2.5 to 3 times higher in Yolo and Solano Counties compared to the contribution results using the "Current Draft Inventory" scaling factors. However, because Yolo and Solano Counties contributions are small, the absolute increase in contribution is also small.
- **Appendix C** contains the TEAK-estimated average percent contribution in the form of data plots for the Del Paso Manor, Folsom, Bruceville, Davis, and Roseville receptors for

the winters of 2007/2008 and 2008/2009 using the "Consistent Inventory Methodology" for the emissions. For each receptor, daily contributions were only included in the average if the observed 24-hr $PM_{2.5}$ concentration was greater than 35.5 $\mu g/m^3$ at the receptor. In general, the results for the site-specific high concentration days were similar to the results for the Sacramento County high concentration days (Appendix B) with the exception of the Davis receptor: Davis' primary $PM_{2.5}$ attributable to wood smoke from Sacramento County increased from 9.0% to 34.5% for the site-specific high concentration days. However, there were only three days in this average.

- **Appendix D** contains the TEAK contribution results in the form of data plots for the Del Paso Manor, Folsom, Bruceville, Davis, and Roseville receptors for December 15, 2000 through January 9, 2001, using the "Consistent Inventory Methodology" for the emissions. These plots were used to help determine whether the TEAK 2000/2001 modeling results were similar to (1) the 2007-2009 TEAK modeling results and (2) the 2000/2001 MM5/CAMx modeling results. In general, the TEAK 2000/2001 results were similar to the 2007-2009 TEAK modeling results: the 2000/2001 MM5/CAMx modeling results likely represent contributions in 2007-2009 as well. In addition, the 2000/2001 TEAK method showed higher contributions from counties outside Sacramento County than did the MM5/CAMx method. Again, this difference was expected because MM5/CAMx included deposition and dispersion, whereas the TEAK method did not. A notable exception is the Roseville receptor for which TEAK and MM5/CAMx results both show a substantial contribution attributable to Placer County.

3. METHODS

The goal of the work described in this report was to determine the contributions that residential wood smoke emissions from urban Sacramento County, rural Sacramento County, Sacramento County as a whole, and surrounding counties make to wood smoke primary $PM_{2.5}$ at several receptor sites. To estimate the contributions, STI conducted two independent model analyses using MM5/CAMx and TEAK. Section 3.1 provides an overview of these methods, Section 3.2 provides details about the MM5/CAMx method, and Section 3.3 provides details about the TEAK method.

3.1 OVERVIEW OF METHODS

For the MM5/CAMx and TEAK modeling, spatially and temporally resolved meteorological model data and wood smoke emissions data were used to estimate daily contributions of wood smoke emissions from rural Sacramento County and surrounding counties to primary $PM_{2.5}$ concentrations at several receptor sites (including Del Paso Manor, Folsom, Bruceville, Davis, Roseville, and Rancho Seco). For each modeling method and receptor site, the daily contribution estimates for high $PM_{2.5}$ days in Sacramento County (i.e., days that exceeded the NAAQS for $PM_{2.5}$) were extracted and average contributions by source regions were calculated (expressed as a percentage of the total contribution for a given day). Histograms were generated for each receptor to show the number of days on which the contribution was within certain ranges for each source county. The histograms were used to determine whether the average contributions were typical of contributions on all high $PM_{2.5}$ days.

The MM5/CAMx and TEAK methods are discussed individually in the sections that follow, and important differences between the MM5/CAMx and TEAK methods are presented below:

- MM5/CAMx was run for December 15, 2000, through January 9, 2001. This period was selected because high resolution meteorological model data were readily available for this range of dates from the California Air Resources Board, and past work verified that the modeled wind fields represented observed winds (Wheeler et al., 2008) (Wheeler et. al. 2005). TEAK was run for the winters (November through February) of 2000/2001, 2007/2008, and 2008/2009. Days in 2000/2001 were included to allow comparison of results between the two methods, while the other two winters were included to capture years during which Rule 421 was in effect. Note: winds in Sacramento on high $PM_{2.5}$ days during 2000/2001, 2007/2008, and 2008/2009 were generally similar among the years.[5] In general, winds were light from the north, northwest, and southeast on high $PM_{2.5}$ days. However, winds on some individual high $PM_{2.5}$ days were different from these typical winds; therefore, the contributions to wood smoke primary $PM_{2.5}$ at a given receptor on any given day may be different from the average contributions.

[5] Wind roses were created by the SMAQMD using hourly wind data collected at Del Paso Manor and were analyzed by STI.

- The MM5/CAMx method used meteorology resolved to 4-km grids, whereas TEAK used meteorology resolved to 80-km grids for 2000/2001 and 40-km grids for 2007 through 2009. Therefore, we expect MM5/CAMx to perform better at resolving local scale flows. It should be noted that, although the grid resolution is coarse for TEAK, TEAK interpolates the gridded data to determine the best estimate of winds at each parcel location.
- The MM5/CAMx method included deposition and turbulent diffusion, whereas the TEAK method did not. Because deposition and turbulent diffusion reduce $PM_{2.5}$ concentrations over time, we expect MM5/CAMx to provide a smaller estimate of contribution from surrounding counties compared to TEAK. However, it should be noted that dry deposition of wood smoke $PM_{2.5}$ is only about one-half percent of the total $PM_{2.5}$ mass per hour. Therefore, reduction of $PM_{2.5}$ due to dry deposition over 24 hours will only be about 10% of the initial mass. It should also be noted that the amount of horizontal dispersion depends on concentration gradients. Because wood smoke emissions are spread over wide areas, concentration gradients (after initial dispersion near smoke stacks) are likely to be small. Therefore, we expect modest concentration reductions due to horizontal dispersion.
- At the request of SMAQMD, the MM5/CAMx method used sub-county source areas (e.g., rural and urban Sacramento County) in addition to entire county source areas; the TEAK method, on the other hand, used 4-km gridded source areas that were then summed for each county, but not for sub-county source areas.
- The receptors for both methods included Del Paso Manor, Folsom, Bruceville, Davis, and Roseville. In addition, at the request of SMAQMD, the MM5/CAMx method included Rancho Seco.

3.2 CONTRIBUTION ASSESSMENT USING MM5/CAMX

STI performed an inert tracer sensitivity analysis using CAMx version 4.51 (ENVIRON International Corporation, 2008) to evaluate the potential for regional impacts from wood smoke emissions in rural Sacramento County and surrounding counties during wintertime pollution episodes. Modeling was performed on the Central California Air Quality Studies (CCAQS) modeling domain, a 185 by 185 grids with a 4-km grid resolution that covers northern and central California (see **Figure 3-1**).

Figure 3-1. CCAQS modeling domain for source contribution analysis.

The study period selected for this analysis, December 15, 2000, through January 9, 2001. coincides with a multi-day wintertime $PM_{2.5}$ pollution episode in the Sacramento and San Joaquin Valleys that was analyzed and modeled extensively as part of the California Regional $PM_{10}/PM_{2.5}$ Air Quality Study (CRPAQS). Stagnation conditions in the Central Valley were prevalent during this period, with intermittent periods of fog. The meteorological conditions that prevailed during this period are typical of conditions in which residential wood smoke could contribute significantly to the total $PM_{2.5}$ concentration in Sacramento County.

Twenty-one residential wood smoke emission source contribution regions were defined by the SMAQMD for the CAMx source contribution modeling analysis (see **Table 3-1** and **Figures 3-2 and 3-3**). These source regions consisted primarily of single counties or sub-county areas, although contributions from multiple counties surrounding the main region of interest were summed together. No emissions from outside California were included. Unique CAMx tracers were defined for each source region, so that wood smoke emissions from each source region could be tracked. Emissions from other sources were excluded to isolate source contributions from wood smoke emissions.

Table 3-1. Source regions used in the contribution analysis.

Source Number	Source Region Description
1	Northern Sacramento Urban Area [a]
2	Southern Sacramento Urban Area [b]
3	Sacramento Rural Area [c]
4	El Dorado County $PM_{2.5}$ Nonattainment Area
5	El Dorado County $PM_{2.5}$ Attainment Area
6	Placer County $PM_{2.5}$ Nonattainment Area
7	Placer County $PM_{2.5}$ Attainment Area
8	Solano County $PM_{2.5}$ Nonattainment Area
9	Solano County $PM_{2.5}$ BAAQMD portion
10	Yolo County $PM_{2.5}$ Nonattainment Area
11	Yolo County $PM_{2.5}$ Attainment Area
12	Yuba and Sutter Counties
13	Butte County
14	Nevada County
15	Contra Costa County
16	Amador County
17	Calaveras County
18	San Joaquin County
19	Stanislaus County
20	Alameda County
21	Distant Counties

[a] Includes the cities of Sacramento, Citrus Heights, Folsom, and Rancho Cordova and the unincorporated areas around these cities.
[b] Includes Elk Grove and Galt and the unincorporated areas around these cities.
[c] All of Sacramento County not included in sub-regions 1 and 2.

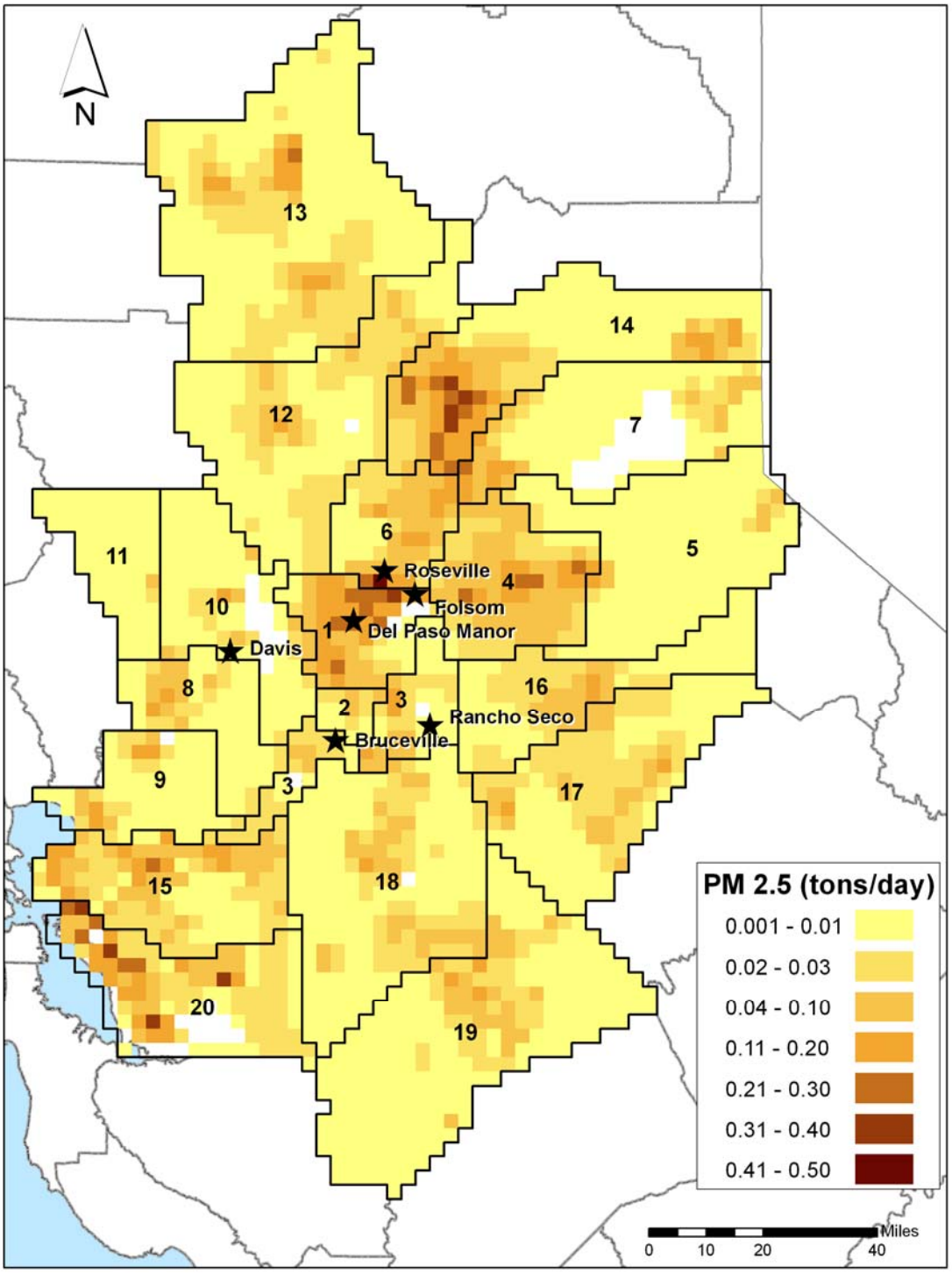

Figure 3-2. Source contribution regions and gridded wood smoke emissions. Undesignated regions were collectively assigned to source region 21 (the Distant Counties source region). White areas within the 20 sources areas have zero emissions.

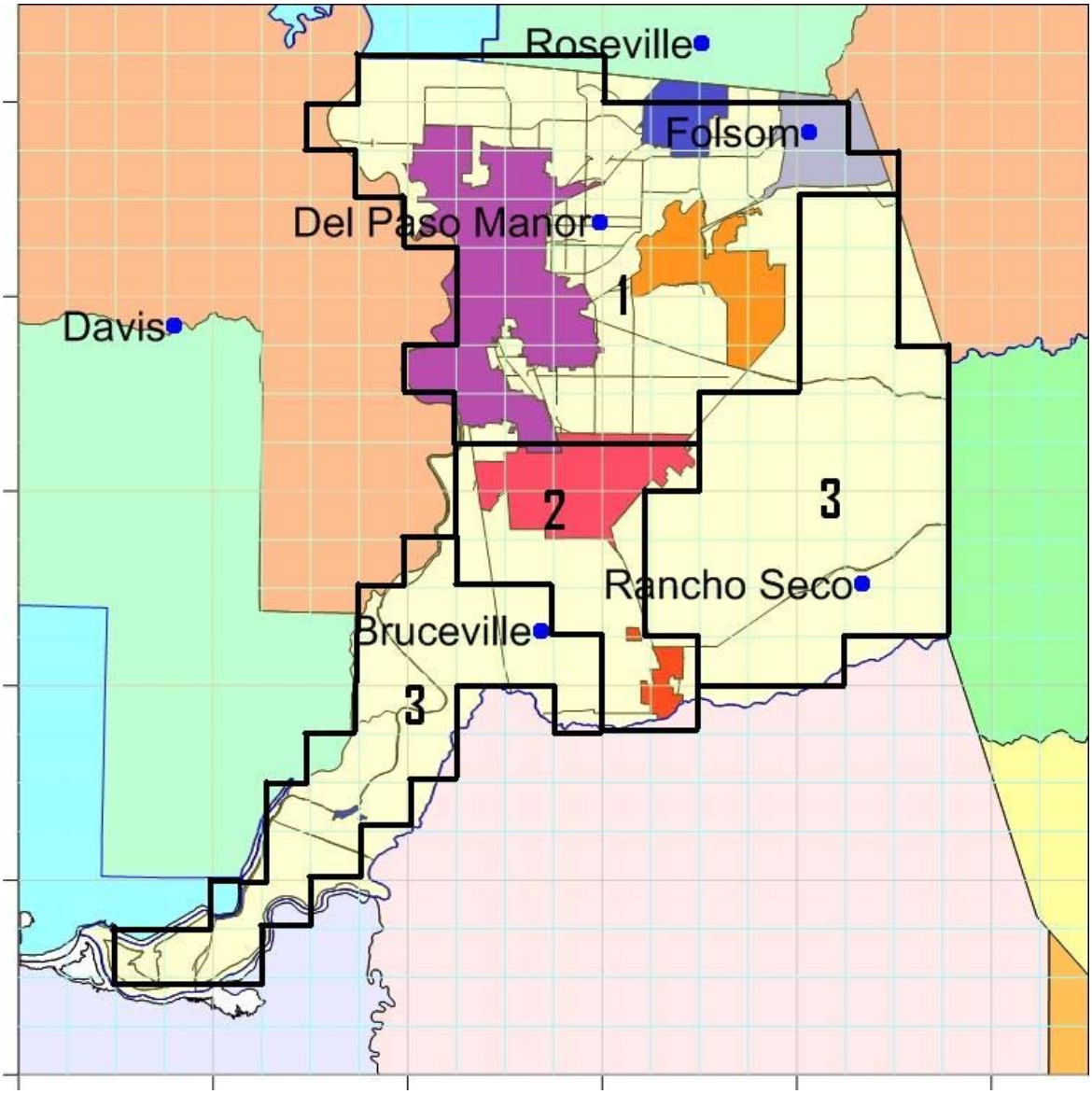

Figure 3-3. Source contribution regions within Sacramento County.

Gridded residential wood smoke emissions data were developed from 2009 county-level average winter day emissions provided by the SMAQMD (see Figure 3-2). During post-processing, adjustments were made to the contribution estimates to account for emission inventory changes that occurred during the course of this project (as discussed on page 3-5). The original emissions provided by SMAQMD were based on the California Air Resources Board (ARB) emissions inventory, version 1.06, which uses a 2002 base year. County-level emissions were spatially allocated by using census data, developed during the California Regional $PM_{10}/PM_{2.5}$ Air Quality Study (Magliano et al., 1999), on households with wood heating as the primary heating source. Emissions were spatially and temporally allocated using the Sparse Matrix Operator Kernel Emissions (SMOKE) Modeling System. The default SMOKE diurnal profile for residential wood combustion was replaced with a more appropriate profile developed

by the ARB. It is assumed that wood smoke emissions do not vary by the day of the week, so weekday and weekend emissions rates are equal.

As part of the CRPAQS modeling analysis, ARB performed MM5 simulations on the CCAQS modeling domain at a 4-km resolution for this study period. The MM5/CAMx preprocessing program was used to translate the MM5 output into a CAMx-ready format. The original 30-layer MM5 vertical grid structure was preserved for the CAMx simulation to minimize vertical interpolation errors when mapping MM5 data to the CAMx grid. Vertical diffusivity fields were derived using the method of (O'Brien, 1970).

CAMx aerosol tracers were assumed to be chemically inert and were subjected to advection, turbulent diffusion, and wet and dry deposition processes in the model. Aerosol density was assumed to be 1.0 g/cm^3, and aerosols were assumed to have a radius of less than 2.5 microns. No contributions were allowed at the top and lateral model boundaries.

Daily average residential wood smoke $PM_{2.5}$ contributions from each source region were calculated from the hourly CAMx output for six receptor locations in the Sacramento area (see **Table 3-2** and Figures 3-2 and 3-3). These daily average contributions were used in subsequent analyses.

Table 3-2. Receptor locations for the MM5/CAMx source contribution analysis.

Receptor Site Name	Coordinates	Location
Del Paso Manor	38.61N, 121.37W	North-Central Sacramento County
Davis	38.53N, 121.78W	Yolo County
Roseville	38.75N, 121.27W	Placer County
Folsom	38.68N, 121.16W	Northeast Sacramento County
Rancho Seco	38.34N, 121.11W	Southeast Sacramento County
Bruceville	38.30N, 121.42W	Southwest Sacramento County

After these modeling simulations were completed, two sets of updated residential wood smoke emissions data for selected counties were provided by the SMAQMD in the form of county-level scaling factor adjustments to the original inventory used in the modeling. These updated emissions were used to reflect likely changes to the emission inventory by the ARB. Because the modeling in this analysis deals only with inert, primary $PM_{2.5}$ emissions, it can be assumed that the absolute wood smoke contribution from a source region is linearly proportional to the emission rate in that source region. Therefore, these scaling factor adjustments were applied to the predicted daily average residential wood smoke $PM_{2.5}$ contributions. For counties represented by multiple source regions, the appropriate scaling factor was applied to all source regions in that county. For example, the Sacramento County emissions scaling factor was applied to data from all three Sacramento source contribution regions. The findings presented in this section are based on the emission scaling factors called "Current Draft Inventory", shown in **Table 3-3**. The results presented in Appendix B of this report use the scaling factors called "Consistent Inventory Methodology", shown in **Table 3-4**.

Table 3-3. Residential wood smoke emission inventory scaling factors called the "Current Draft Inventory".

County	Scale Factor
Sacramento	1.22
El Dorado	0.26
Placer	0.75
Yolo	0.85
Solano	0.75

Table 3-4. Residential wood smoke emission inventory scaling factors called the "Consistent Inventory Methodology".

County	Scale Factor
Sacramento	1.22
El Dorado	0.26
Placer	0.85
Yolo	2.71
Solano	2.54

3.3 CONTRIBUTION ASSESSMENT USING TEAK

STI used back trajectories and hourly-resolved wood smoke emissions for Sacramento and surrounding counties to estimate the daily wood smoke contribution from each 4-km grid within the CCAQS modeling domain (see Figure 3-1) to primary $PM_{2.5}$ at selected receptor locations. The contribution estimates were made for each "winter" day in 2000/2001, 2007/2008, and 2008/2009. In particular, air parcel paths arriving at each receptor were calculated using the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT)(Air Resources Laboratory, 2008). HYSPLIT used Eta Data Assimilation System (EDAS) meteorological data. These data have a horizontal resolution of 80 km for 2000/2001 and 40 km for 2007 through 2009. The back trajectories were calculated (1) starting at three elevations for each hour per day from each receptor location and (2) for 36 hours. The starting elevations were 25, 100, and 200 m agl and were selected to capture transport paths at different altitudes in the atmospheric boundary layer. Note that the 25 m agl trajectory represents air flow in the lower portion of the atmospheric boundary layer, including flow in the nocturnal boundary layer; therefore, the 25 m agl trajectory represents the transport of residential wood smoke emitted at night when the boundary layer was shallow and vertical mixing limited. The air parcel backward trajectory time was limited to 36 hours because the reduction in $PM_{2.5}$ concentrations due to dispersion and deposition became more important over time and the TEAK model did not include dispersion and deposition. The average daily maximum atmospheric boundary layer height during typical $PM_{2.5}$ episodes was about 400 m agl and was determined by reviewing findings from the CRPAQS (MacDonald et al., 2003).

During transit, the air parcels were allowed to move vertically by following constant pressure surfaces. This method of vertical motion was selected because tests performed during this project using different vertical motion methods revealed that the constant pressure method provided the most realistic results for the type of stable atmosphere that exists during $PM_{2.5}$ episodes in Sacramento. For example, trajectories calculated using the constant pressure method remained in the boundary layer under stable atmospheric conditions, whereas trajectories calculated using other methods did not. An example of backward trajectories arriving each hour of the day at Del Paso Manor is shown in **Figure 3-4.**

For each trajectory, air parcel locations and altitude during transit were recorded at 15-minute time steps. The short time step was selected to ensure that no grid cells were skipped when allocating emissions to air parcels during transit. At each location, the air parcels were "tagged" with wood smoke emissions coincident in time and space. The gridded wood smoke emissions data were developed from 2009 county-level average winter day emissions provided by the SMAQMD, as discussed in Section 3.2. However, "tagging" of air parcels with coincident wood smoke emissions at each time step occurred only if the air parcel was in the atmospheric boundary layer, because air parcels above the atmospheric boundary layer would not be impacted by wood smoke emissions from residential wood burning. For example, at night, only air parcels in the nocturnal boundary layer (e.g., air parcels at an altitude less than ~50 m agl) were "tagged" by the wood smoke emissions. The hourly atmospheric boundary layer heights were determined from the CRPAQS findings (MacDonald et al., 2003). In addition, if an air parcel arrived at a receptor and was above the atmospheric boundary layer at the time of arrival, it was not counted as a contributor to surface $PM_{2.5}$ concentration.

Using the "tagged" air parcel information, daily spatial maps of the percent contribution to each receptor were created. A sample contribution map is shown in **Figure 3-5**. Information from the maps was then used to determine the total contribution by county and day to each receptor shown in **Table 3-5**. These daily average contributions were used in subsequent analyses.

After the simulations were completed, updated residential wood smoke emissions data were made available by the SMAQMD in the form of county-level scaling factor adjustments to the original inventory (see Table 3-3). Because the modeling in this analysis deals only with inert, primary $PM_{2.5}$ emissions, it can be assumed that the absolute wood smoke contribution from a source region is linearly proportional to the emission rate in that source region. Therefore, these scaling factor adjustments were applied to the TEAK-predicted daily average residential wood smoke $PM_{2.5}$ contributions. For counties represented by multiple source regions, the appropriate scaling factor is applied to all source regions in that county. For example, the Sacramento County emissions scaling factor was applied to data from all three Sacramento source contribution regions.

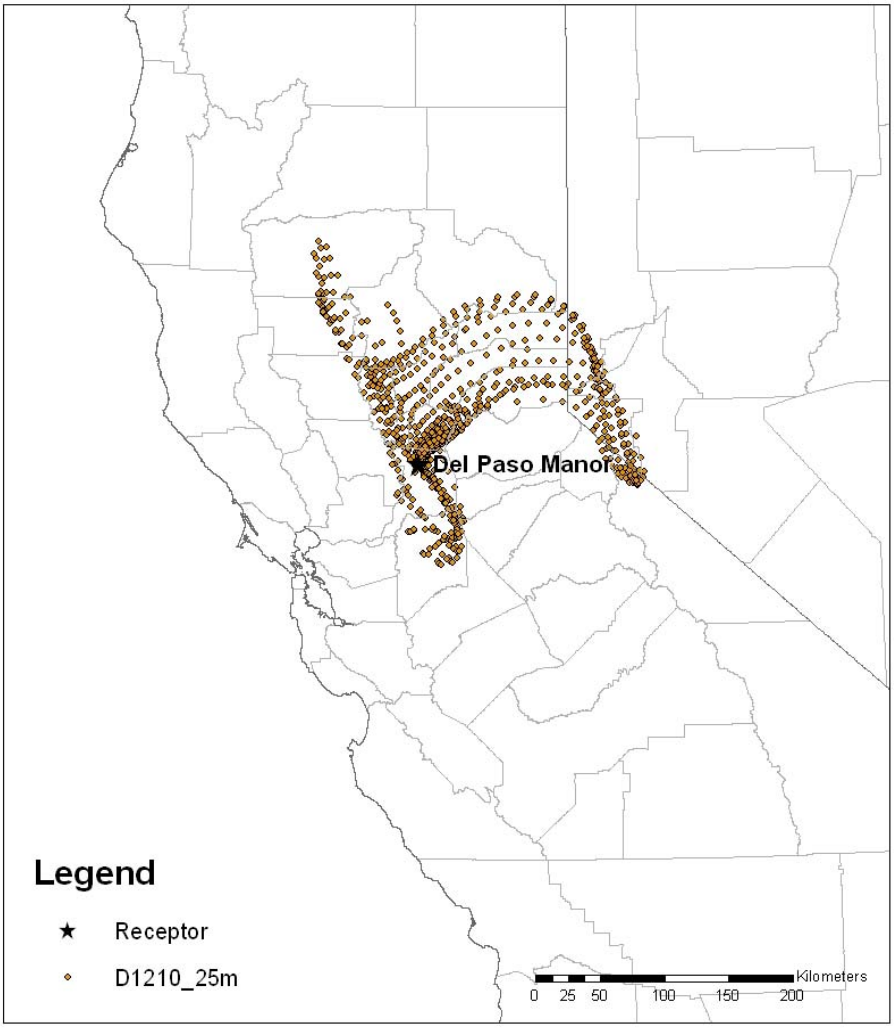

Figure 3-4. Thirty-six-hour backward trajectories ending at Del Paso Manor at 25 m agl every hour on December 10, 2008.

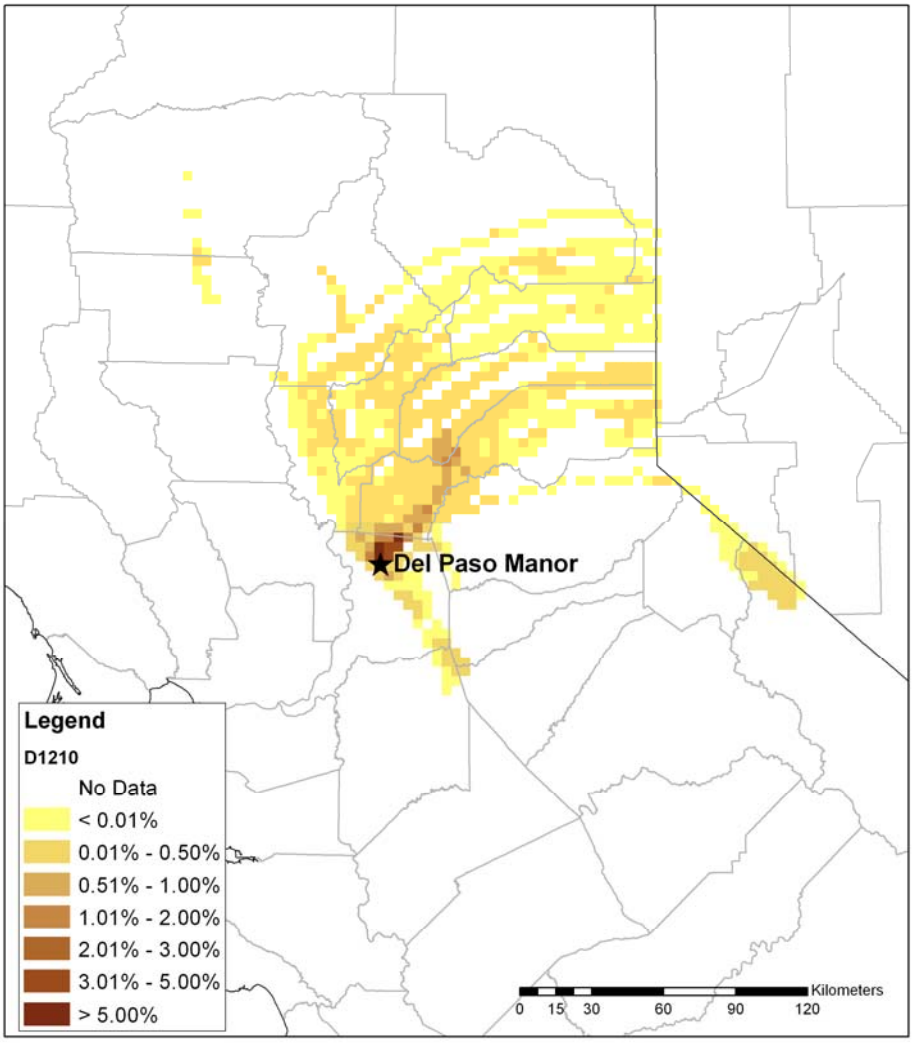

Figure 3-5. Gridded percent contribution to primary $PM_{2.5}$ at Del Paso Manor on December 10, 2008.

Table 3-5. Receptor locations for the TEAK source contribution analysis.

Receptor Site Name	Coordinates	Location
Del Paso Manor	38.61N, 121.37W	North-Central Sacramento County
Davis	38.53N, 121.78W	Yolo County
Roseville	38.75N, 121.27W	Placer County
Folsom	38.68N, 121.16W	Northeast Sacramento County
Bruceville	38.30N, 121.42W	Southwest Sacramento County

4. RESULTS

This section presents the results that were used to derive the key findings presented in Section 2. For each receptor site—Del Paso Manor, Folsom, and Bruceville—two questions are addressed. After each question, the related findings are presented and organized by analysis method (MM5/CAMx or TEAK). Please note that results for sub-county source areas are available only for the MM5/CAMx method. Appendix A contains information for the other receptors not discussed: Davis, Roseville, and Rancho Seco.

Please recall that MM5/CAMx was run for December 15, 2000, through January 9, 2001, and TEAK was run for the winters (November through February) of 2000/2001, 2007/2008, and 2008/2009. Winds in Sacramento on high $PM_{2.5}$ days during 2000/2001, 2007/2008, and 2008/2009 were generally similar among the years. However, winds on some individual high $PM_{2.5}$ days were different from the typical winds describe in the prior sentence. This means that on any given day, the contributions to wood smoke primary $PM_{2.5}$ at a given receptor may be different from the average contributions.

4.1 DEL PASO MANOR

Del Paso Manor was selected for analysis because that site has the greatest number of $PM_{2.5}$ exceedances in Sacramento County.

Question 1: What was the average contribution to wood smoke primary $PM_{2.5}$ at Del Paso Manor from residential wood smoke emissions from urban and rural Sacramento County, Sacramento County as a whole, and surrounding counties on days when peak concentrations within Sacramento County exceeded 35.5 $\mu g/m^3$?

Findings from MM5/CAMx

Figure 4-1 shows a pie chart of the average percentage contribution by county and sub-county to wood smoke primary $PM_{2.5}$ at Del Paso Manor for all days from December 15, 2000, through January 9, 2001. Contributions from individual counties of less than 1% each were summed together and called "Other Counties". Counties outside the 20 counties/sub-counties shown in Table 3-1 were also summed and called "Distant Counties". **Figure 4-2** provides a spatial map showing the same information as Figure 4-1. These figures show that, on average,

- residential wood smoke emissions from Sacramento County contributed 84% of the wood smoke primary $PM_{2.5}$ at Del Paso Manor (Northern Sacramento Urban Area [80%], Sacramento Rural Area [3%], and Southern Sacramento Urban Area [1%]);
- the next significant (i.e., greater than 3%) contributors were Distant Counties (5%) and Yuba and Sutter Counties (3%); and
- residential wood smoke emissions from Sacramento Rural Area contributed 3%.

Findings from TEAK

Figure 4-3 provides the same type of information as Figure 4-1, but for all high $PM_{2.5}$ days from the winters of 2007/2008 and 2008/2009 and from TEAK. **Figure 4-4** provides a spatial map showing the same information as Figure 4-3. These figures show that, on average,

- residential wood smoke emissions from Sacramento County contributed 63% of the wood smoke primary $PM_{2.5}$ at Del Paso Manor; and
- the next significant (i.e., greater than 3%) contributors were Placer County (8%), Nevada County (8%), and Other Counties (6%).

Question 2: Are there days when the contribution to wood smoke primary $PM_{2.5}$ at Del Paso Manor from rural Sacramento County and surrounding counties is much different from the average contribution?

Findings from MM5/CAMx

Figure 4-5 shows the number of days on which the contribution to wood smoke primary $PM_{2.5}$ at Del Paso Manor was within certain ranges for each county. The contribution ranges were 0-12.4%, 12.5-24.9%, 25.0-49.9%, 50-74.9%, and 75.0-100 %. Only source counties with an average contribution of greater than 1% are shown. Dates were from December 15, 2000, through January 9, 2001. These figures show that there were no days when the contribution from rural Sacramento County and surrounding counties was significantly larger than the average contribution for all days (the average contribution for all days is presented under Question 1 above).

Findings from TEAK

Figure 4-6 provides the same type of information as Figure 4-5, but for all high days in the winters of 2007/2008 and 2008/2009. These figures show that there were some days when the contribution from Nevada and Placer Counties were significantly larger than the average contribution for all days (the average contribution for all days is presented under Question 1 above). In particular,

- on 9 of the 33 high days, residential wood smoke emissions from Nevada County contributed 12.5-49.9% to the wood smoke primary $PM_{2.5}$ at Del Paso Manor; and
- on 8 of the 33 high days, residential wood smoke emissions from Placer County contributed 12.5-49.9% to the wood smoke primary $PM_{2.5}$ at Del Paso Manor.

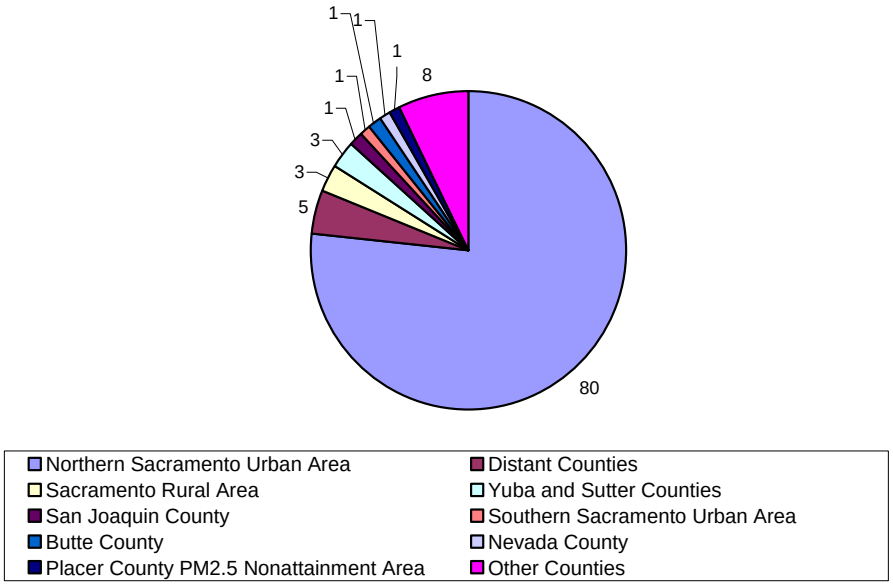

Figure 4-1. MM5/CAMx estimated average **percent** contribution from each county or sub-county to Del Paso Manor wood smoke primary $PM_{2.5}$ from December 15, 2000, through January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

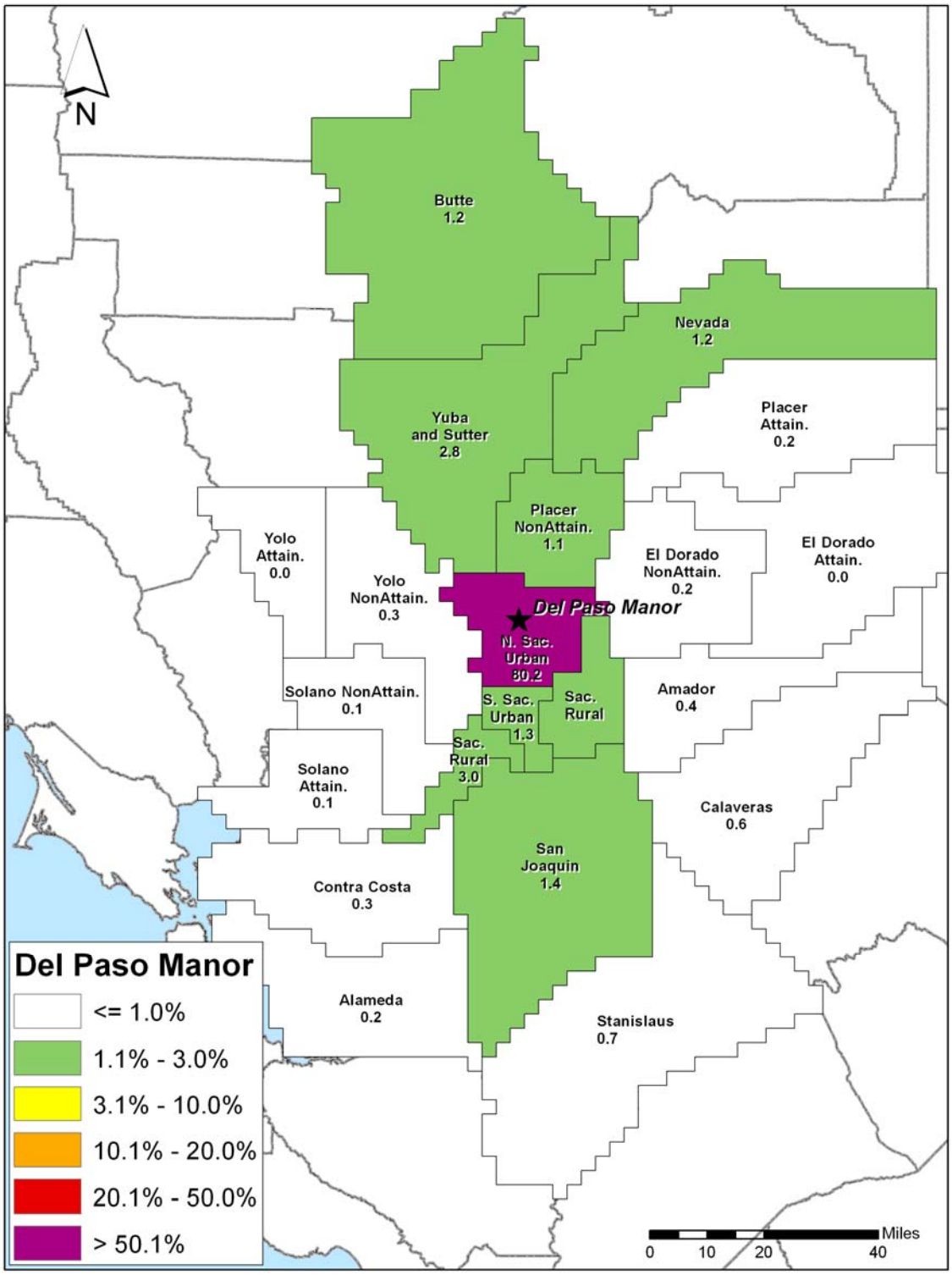

Figure 4-2. Spatial plot of the MM5/CAMx estimated average **percent** contribution from each county or sub-county to Del Paso Manor wood smoke primary $PM_{2.5}$ from December 15, 2000, through January 9, 2001.

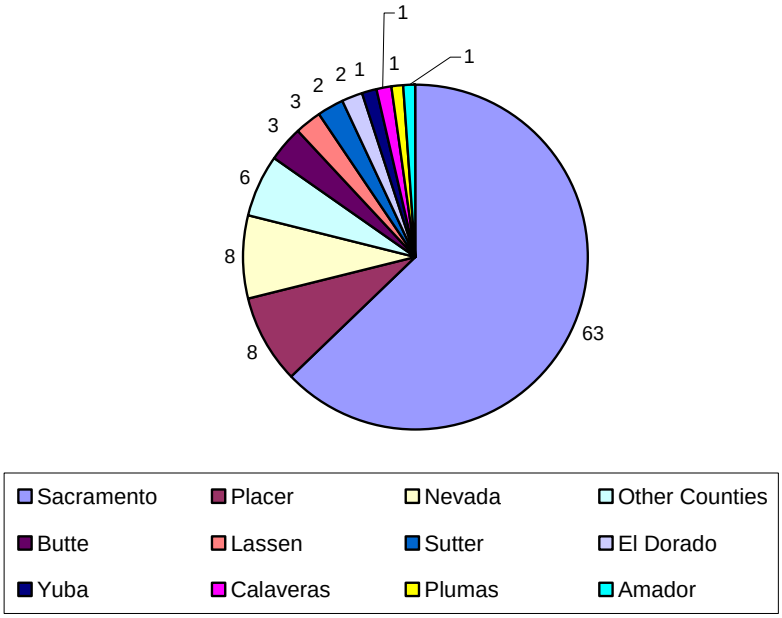

Figure 4-3. TEAK estimated average **percent** contribution from each county to Del Paso Manor wood smoke primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

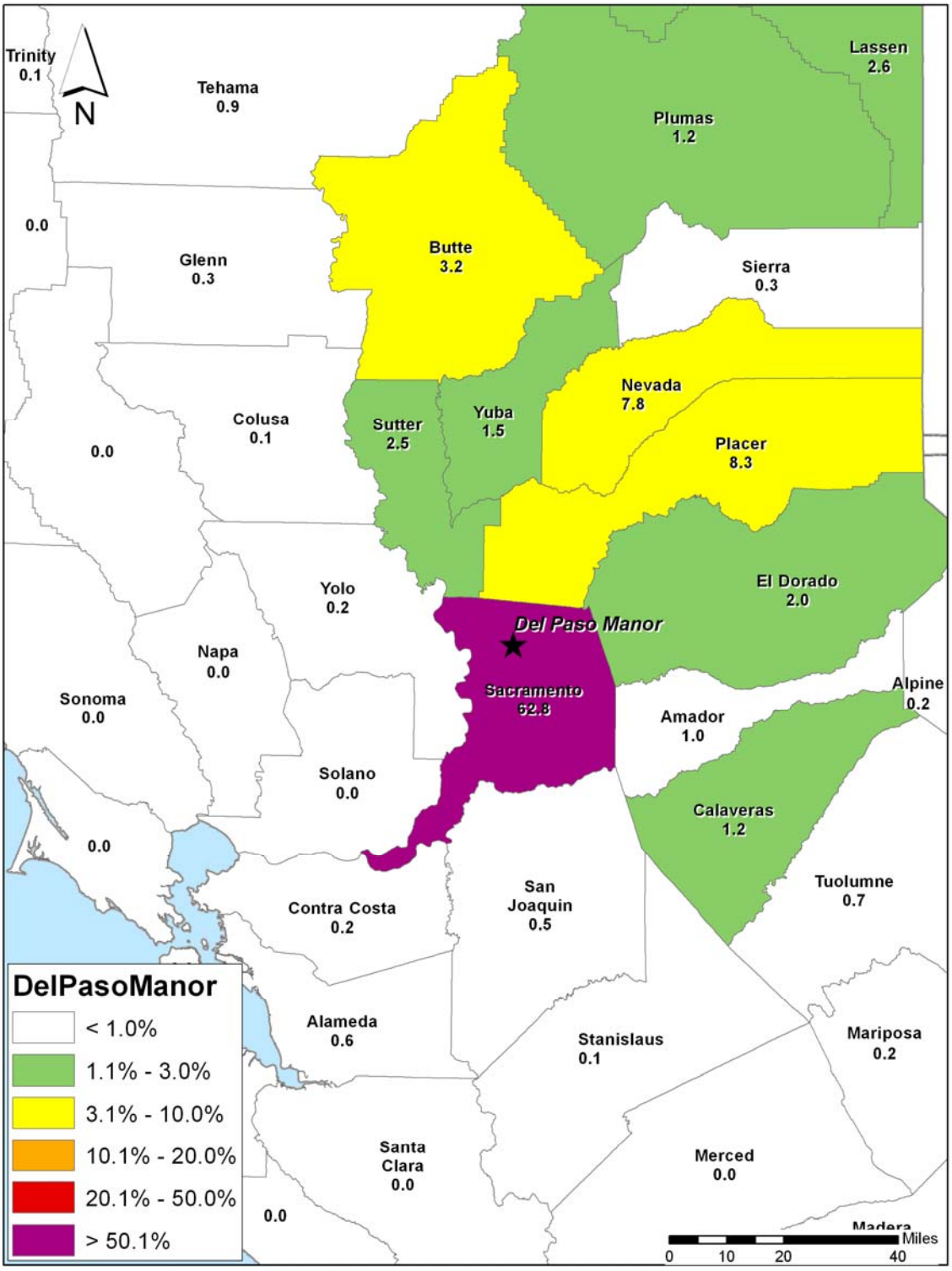

Figure 4-4. Spatial plot of the TEAK estimated average **percent** contribution from each county to Del Paso Manor wood smoke primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009.

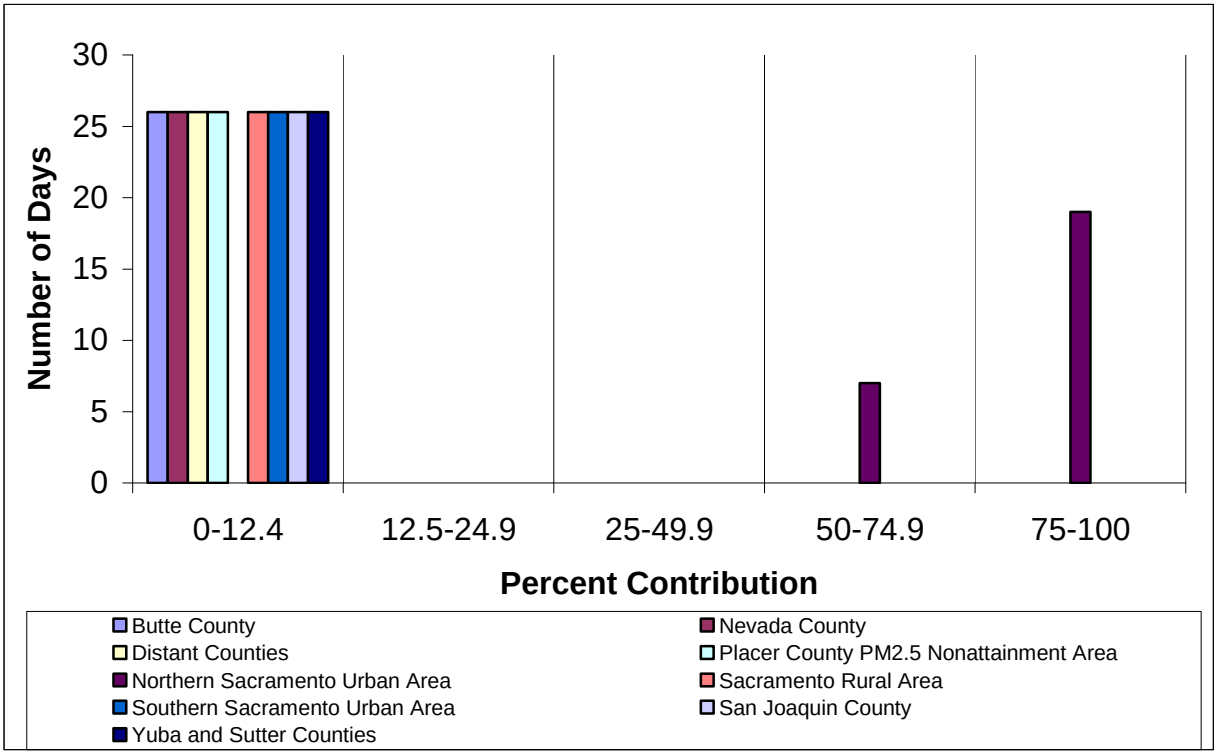

Figure 4-5. MM5/CAMx histogram results showing the number of days within various contribution bins by county for Del Paso Manor from December 15, 2000, through January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

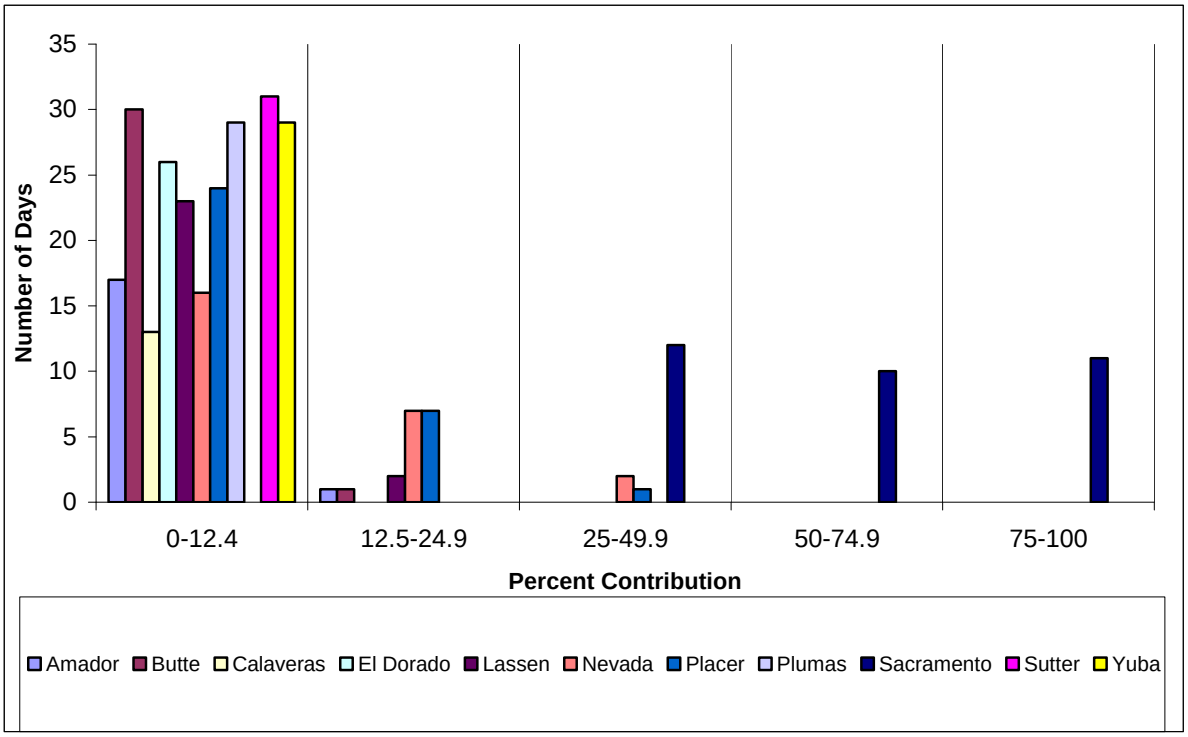

Figure 4-6. TEAK histogram results showing the number of days within various contribution bins by county for Del Paso Manor on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

4.2 FOLSOM

Folsom was selected for analysis because of concerns about significant transport of $PM_{2.5}$ to this site from surrounding counties and rural Sacramento County. In addition, although Folsom does not have Federal Reference Monitors (FRMs) to measure $PM_{2.5}$, it does have continuous Beta Attenuation Monitor (BAM) to measure $PM_{2.5}$. The daily 24-hr BAM data show that the Folsom monitoring site is just below the NAAQS for $PM_{2.5}$. Therefore, implementing no-burn days in this area may reduce localized poor air quality and improve health.

Question 1: What was the average contribution to wood smoke primary $PM_{2.5}$ at Folsom from residential wood smoke emissions from urban and rural Sacramento County, Sacramento County as a whole, and surrounding counties on days when peak concentrations within Sacramento County exceeded 35.5 µg/m^3?

Findings from MM5/CAMx

Figure 4-7 shows a pie chart of the average percentage contribution by county and sub-county to wood smoke primary $PM_{2.5}$ at Folsom for all days from December 15, 2000, through January 9, 2001. Contributions from individual counties of less than 1% each are summed together and called "Other Counties". Counties that are outside the 20 counties/sub-

counties shown in Table 3-1 were also summed and called "Distant Counties". **Figure 4-8** provides a spatial map showing the same information as Figure 4-7. These figures show that, on average,

- residential wood smoke emissions from Sacramento County contributed 57% of the wood smoke primary $PM_{2.5}$ at Folsom (Northern Sacramento Urban Area (54%), Southern Sacramento Urban Area (1%), and Rural Sacramento Area (2%)); and
- the next significant (i.e., greater than 3%) contributors were the Placer County $PM_{2.5}$ Nonattainment Area (13%), Distant Counties (6%), the El Dorado County $PM_{2.5}$ Nonattainment Area (5%), and Nevada County (5%).

Findings from TEAK

Figure 4-9 provides the same type information as Figure 4-7 but for all high $PM_{2.5}$ days in the winters of 2007/2008 and 2008/2009. **Figure 4-10** provides a spatial map showing the same information as Figure 4-9. These figures show that, on average,

- residential wood smoke emissions from Sacramento County contributed 39% of the wood smoke primary $PM_{2.5}$ at Folsom; and
- the next significant (i.e., greater than 3%) contributors were Placer County (19%), Nevada County (15%), and El Dorado County (11%).

Question 2: Are there days when the contribution to wood smoke primary $PM_{2.5}$ at Folsom from rural Sacramento County and surrounding counties is much different from the average contribution?

Findings from MM5/CAMx

Figure 4-11 shows the number of days on which the contribution to primary wood smoke $PM_{2.5}$ at Folsom was within certain ranges for each county. The contribution ranges were 0-12.4%, 12.5-24.9%, 25.0-49.9%, 50-74.9%, and 75.0-100 %. Only source counties with an average contribution of greater than 1% are shown. Dates were from December 15, 2000, through January 9, 2001. These figures show that there are some days when the contribution from rural Sacramento County, Placer County, and Distant Counties is significantly larger than the average contribution for all days (the average contribution for all days is presented under Question 1 above). In particular,

- on 13 of the 26 days, residential wood smoke emissions from Placer County contributed 12.5-49.9% of the wood smoke primary $PM_{2.5}$ at Folsom;
- on 1 of the 26 days, residential wood smoke emission from Sacramento Rural Area contributed 12.5-24.9% of the wood smoke primary $PM_{2.5}$ at Folsom; and
- on 3 of the 26 days, residential wood smoke emissions from Distant Counties contributed 12.5-24.9% of the wood smoke primary $PM_{2.5}$ at Folsom.

Findings from TEAK:

Figure 4-12 provides the same type of information as Figure 4-11, but for all high days from the winters of 2007/2008 and 2008/2009. These figures show that there are some days

when the contribution from Distant Counties is significantly larger than the average contribution for all days (the average contribution for all days is presented under Question 1 above). In particular,

- on 16 of the 33 high days, residential wood smoke emissions from Nevada County contributed 12.5-49.9% of the wood smoke primary $PM_{2.5}$ at Folsom;
- on 21 of the 33 high days, residential wood smoke emissions from Placer County contributed 12.5-49.9% of the wood smoke primary $PM_{2.5}$ at Folsom;
- on 1 of the 33 high days, residential wood smoke emissions from Butte County contributed 12.5-24.9 % of the wood smoke primary $PM_{2.5}$ at Folsom;
- on 3 of the 33 high days, residential wood smoke emissions from Calaveras County contributed 12.5-24.9% of the wood smoke primary $PM_{2.5}$ at Folsom;
- on 11 of the 33 high days, residential wood smoke emissions from El Dorado County contributed 12.5-49.9% of the wood smoke primary $PM_{2.5}$ at Folsom;
- on 1 of the 33 high days, residential wood smoke emissions from Amador, Lassen, and Mono County contributed 25-49.9 % of the wood smoke primary $PM_{2.5}$ at Folsom;
- on 10 of the 33 high days, residential wood smoke emissions from Sacramento County contributed 50-74.9% of the wood smoke primary $PM_{2.5}$ at Folsom; and
- on 1 of the 33 high days, residential wood smoke emissions from Tuolumne County contributed 50-74.9% of the wood smoke primary $PM_{2.5}$ at Folsom.

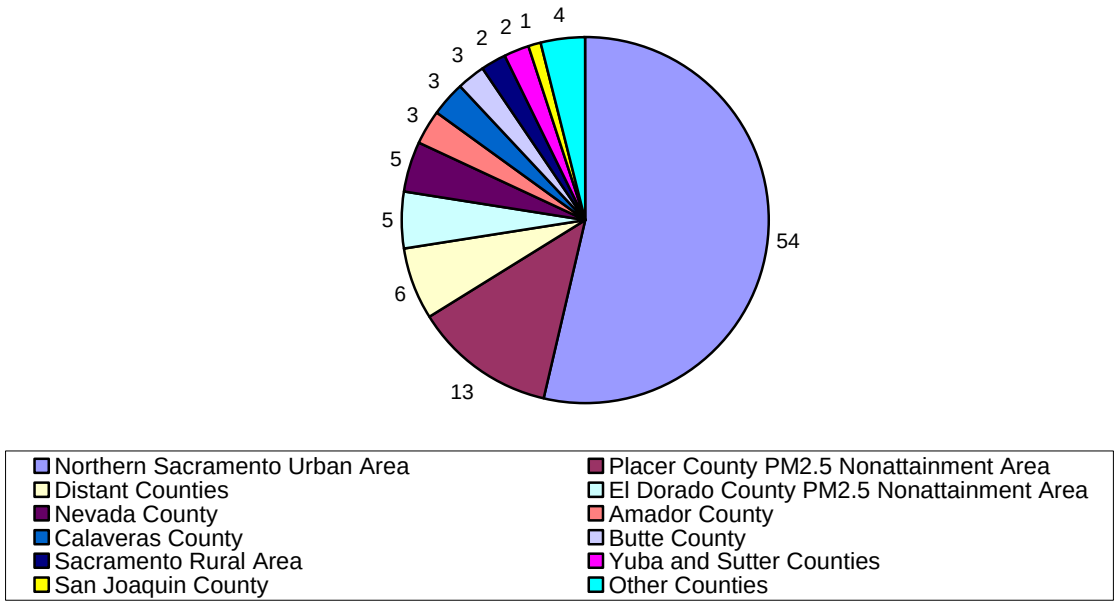

Figure 4-7. MM5/CAMx estimated average **percent** contribution from each county or sub-county to Folsom wood smoke primary $PM_{2.5}$ from December 15, 2000, through January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

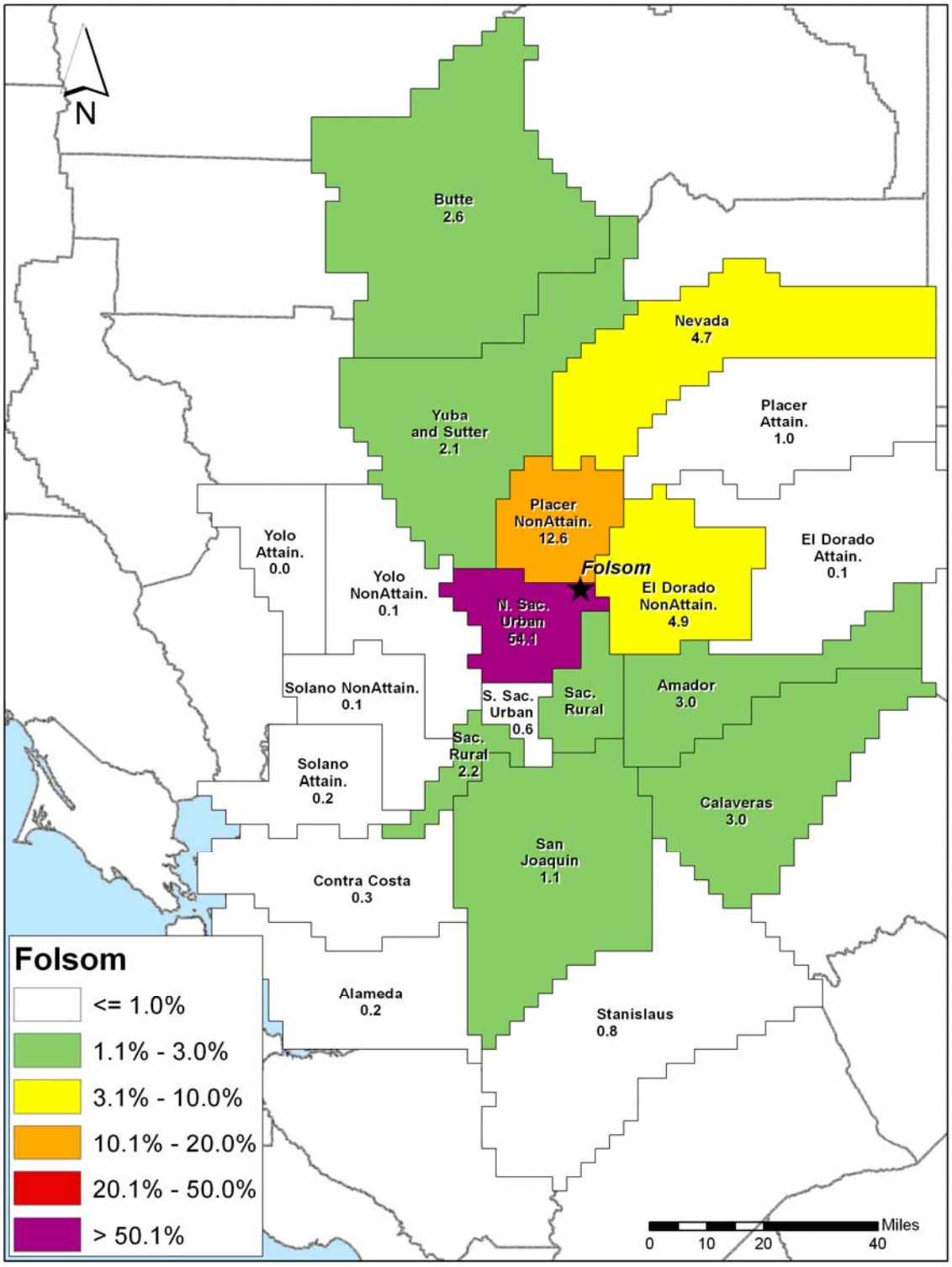

Figure 4-8. Spatial plot of the MM5/CAMx estimated average **percent** contribution from each county or sub-county to Folsom wood smoke primary $PM_{2.5}$ from December 15, 2000, through January 9, 2001.

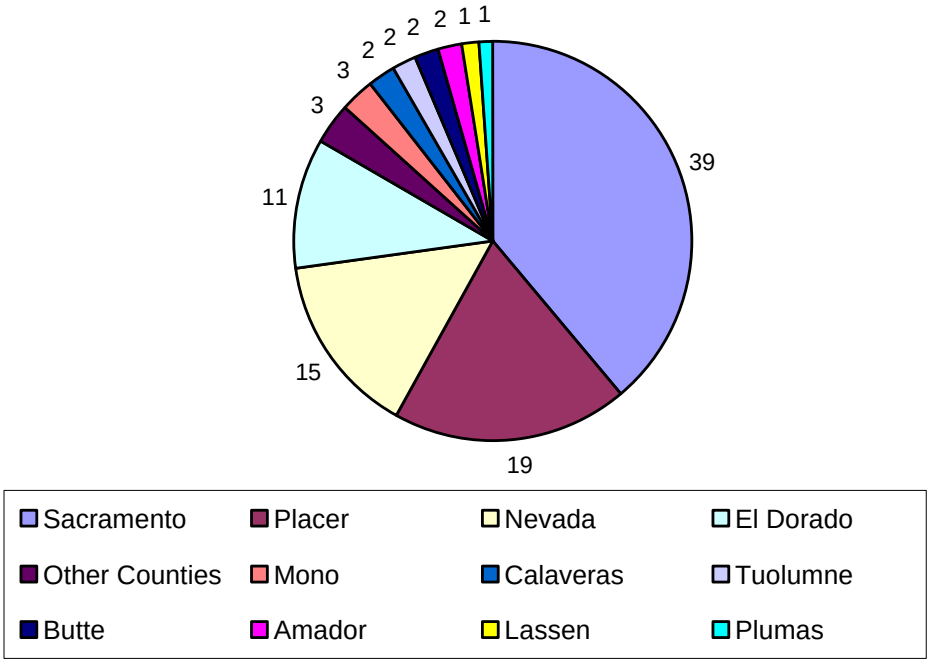

Figure 4-9. TEAK estimated average **percent** contribution from each county to Folsom wood smoke primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

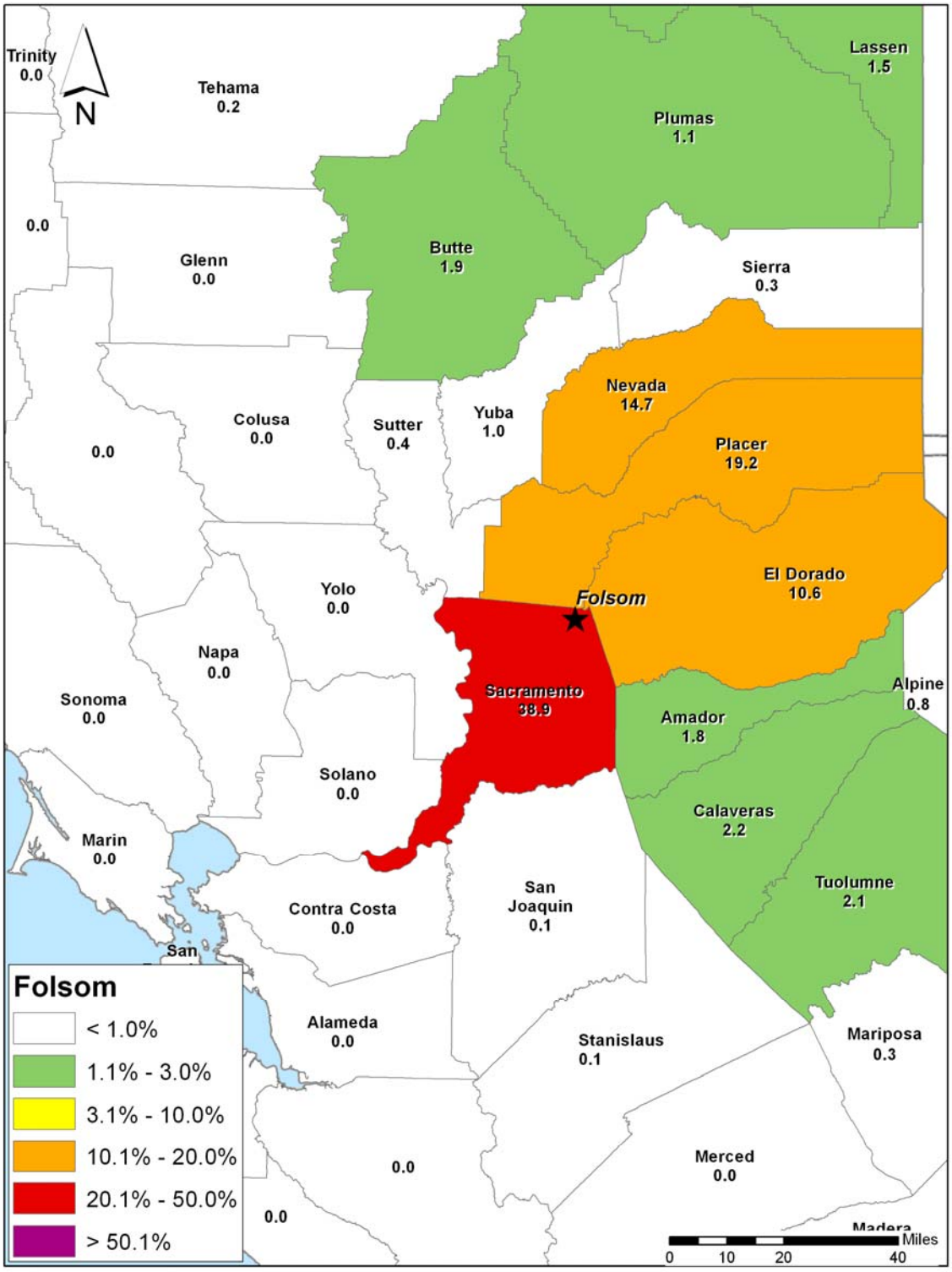

Figure 4-10. Spatial plot of the TEAK estimated average **percent** contribution from each county to Folsom wood smoke primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009.

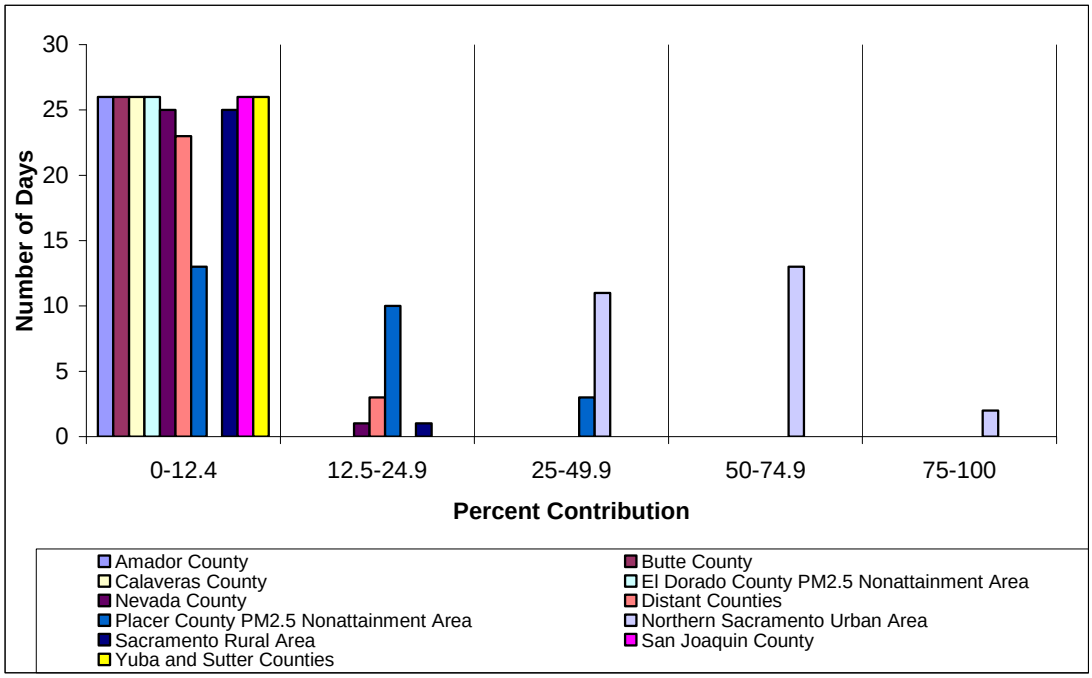

Figure 4-11. MM5/CAMx histogram results showing the number of days within various contribution bins by county for Folsom from December 15, 2000, through January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

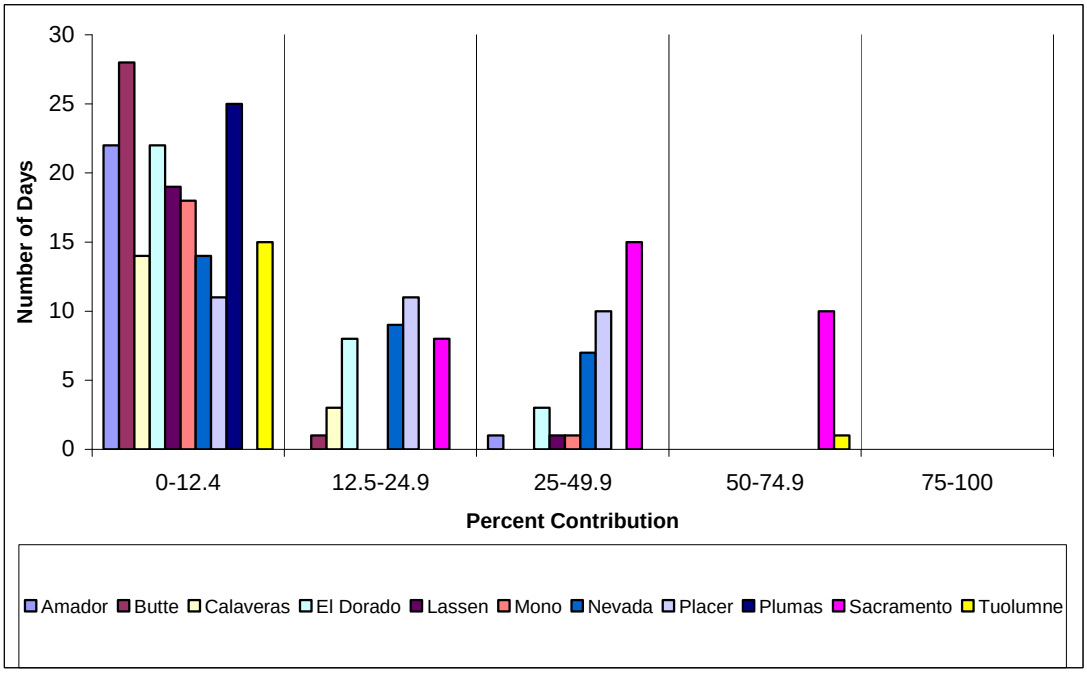

Figure 4-12. TEAK histogram results showing the number of days within various contribution bins by county for Folsom on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

4.3 BRUCEVILLE

Bruceville was selected for analysis because of concerns about significant transport of $PM_{2.5}$ to this site from surrounding counties and rural Sacramento County. In addition, although Bruceville does not have FRMs to measure $PM_{2.5}$, it does have a continuous BAM to measure $PM_{2.5}$. The daily 24-hr BAM data show that the Bruceville monitoring site is just above the NAAQS for $PM_{2.5}$. Therefore, implementing no-burn days in this area may reduce localized poor air quality and improve health.

Question 1: What was the average contribution to wood smoke primary $PM_{2.5}$ at Bruceville from residential wood smoke emissions from urban and rural Sacramento County, Sacramento County as a whole, and surrounding counties on days when peak concentrations within Sacramento County exceeded 35.5 $\mu g/m^3$?

Findings from MM5/CAMx

Figure 4-13 shows a pie chart of the average percentage contribution by county and sub-county to primary $PM_{2.5}$ at Bruceville all days from December 15, 2000, through January 9, 2001. Contributions from individual counties of less than 1% each are summed together and called "Other Counties". Counties outside the 20 counties/sub-counties shown in Table 3-1 were also summed and called "Distant Counties". **Figure 4-14** provides a spatial map showing the same information as Figure 4-13. These figures show that, on average,

- residential wood smoke emissions from Sacramento County contributed 54% of the wood smoke primary $PM_{2.5}$ at Bruceville (Northern Sacramento Urban Area [27%], Sacramento Rural Area [15%], and Southern Sacramento Urban Area [12%]);
- the next significant (i.e., greater than 3%) contributors were Distant Counties (14%), San Joaquin County (10%), Stanislaus County (4%), and Yuba and Sutter Counties (4%); and
- residential wood smoke emissions from Sacramento Rural Area contributed 15%.

Findings from TEAK

Figure 4-15 provides the same type of information as Figure 4-13, but for all high $PM_{2.5}$ days from the winters of 2007/2008 and 2008/2009. **Figure 4-16** provides a spatial map showing the same information as Figure 4-15. These figures show that, on average,

- residential wood smoke emissions from Sacramento County contributed 53% of the wood smoke primary $PM_{2.5}$ at Bruceville; and
- the next significant (i.e., greater than 3%) contributors were Other Counties (6%), San Joaquin County (5%), Placer County (4%), and Sutter County (4%).

Question 2: Are there days when the contribution to wood smoke primary $PM_{2.5}$ from rural Sacramento County and surrounding counties to primary $PM_{2.5}$ at Bruceville is much different from the average contribution?

Findings from MM5/CAMx

Figure 4-17 shows the number of days on which the contribution to Bruceville $PM_{2.5}$ was within certain ranges for each county. The contribution ranges were 0-12.4%, 12.5-24.9%, 25.0-49.9%, 50-74.9%, and 75.0-100 %. Only source counties with an average contribution of greater than 1% are shown. Dates were from December 15, 2000, through January 9, 2001. These figures show that there are some days when the contribution from rural Sacramento County and surrounding counties is significantly larger than the average contribution for all days (the average contribution for all days is presented under Question 1 above). In particular,

- on 2 of the 26 days, residential wood smoke emissions from Distant Counties contributed 25–49.9% of the wood smoke primary $PM_{2.5}$ at Bruceville;
- on 1 of the 26 days, residential wood smoke emissions from Northern Sacramento Urban Area contributed 50–74.9% of the wood smoke primary $PM_{2.5}$ at Bruceville;
- on 3 of the 26 days, residential wood smoke emissions from Sacramento Rural Area contributed 25–49.9% of the wood smoke primary $PM_{2.5}$ at Bruceville;
- on 10 of the 26 days, residential wood smoke emissions from San Joaquin County contributed 25–74.9% of the wood smoke primary $PM_{2.5}$ at Bruceville;
- on 12 of the 26 days, residential wood smoke emissions from Southern Sacramento Urban Area contributed 12.5–24.9% of the wood smoke primary $PM_{2.5}$ at Bruceville; and
- on 2 of the 26 days, residential wood smoke emissions from Stanislaus County contributed 12.5–24.9% of the wood smoke primary $PM_{2.5}$ at Bruceville.

Findings from TEAK

Figure 4-18 provides the same information as Figure 4-17, but for all high days from the winters of 2007/2008 and 2008/2009. These figures show that there are some days when the contribution from surrounding counties is significantly larger than the average contribution for all days (the average contribution for all days is presented under Question 1 above). In particular,

- on 1 of the 33 high days, residential wood smoke emissions from Amador, Solano, and Stanislaus County contributed 12.5–24.9% of the wood smoke primary $PM_{2.5}$ at Bruceville;
- on 2 of the 33 high days, residential wood smoke emissions from Butte, Nevada, Placer, Sutter, and Yolo County contributed 12.5–24.9% of the wood smoke primary $PM_{2.5}$ at Bruceville;
- on 8 of the 33 high days, residential wood smoke emissions from San Joaquin County contributed 12.5–49.9% of the wood smoke primary $PM_{2.5}$ at Bruceville;
- on 2 of the 33 high days, residential wood smoke emissions from Lassen and Contra Costa County contributed 12.5-49.9 % of the wood smoke primary $PM_{2.5}$ at Bruceville;
- on 3 of the 33 high days, residential wood smoke emissions from Calaveras County contributed 12.5–24.9% of the wood smoke primary $PM_{2.5}$ at Bruceville;

- on 1 of the 33 high days, residential wood smoke emissions from Shasta County contributed 25–49.9% of the wood smoke primary $PM_{2.5}$ at Bruceville;
- on 3 of 33 high days, residential wood smoke emissions from Tehama County contributed 12.5–49.9% of the wood smoke primary $PM_{2.5}$ at Bruceville.

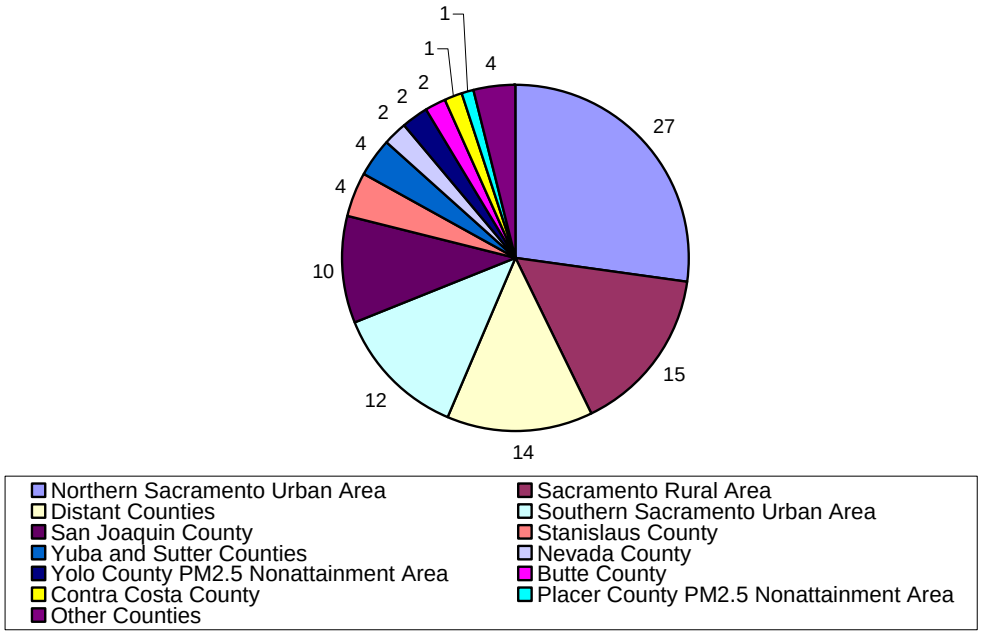

Figure 4-13. MM5/CAMx estimated average **percent** contribution from each county or sub-county to Bruceville wood smoke primary $PM_{2.5}$ during December 15, 2000, through January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

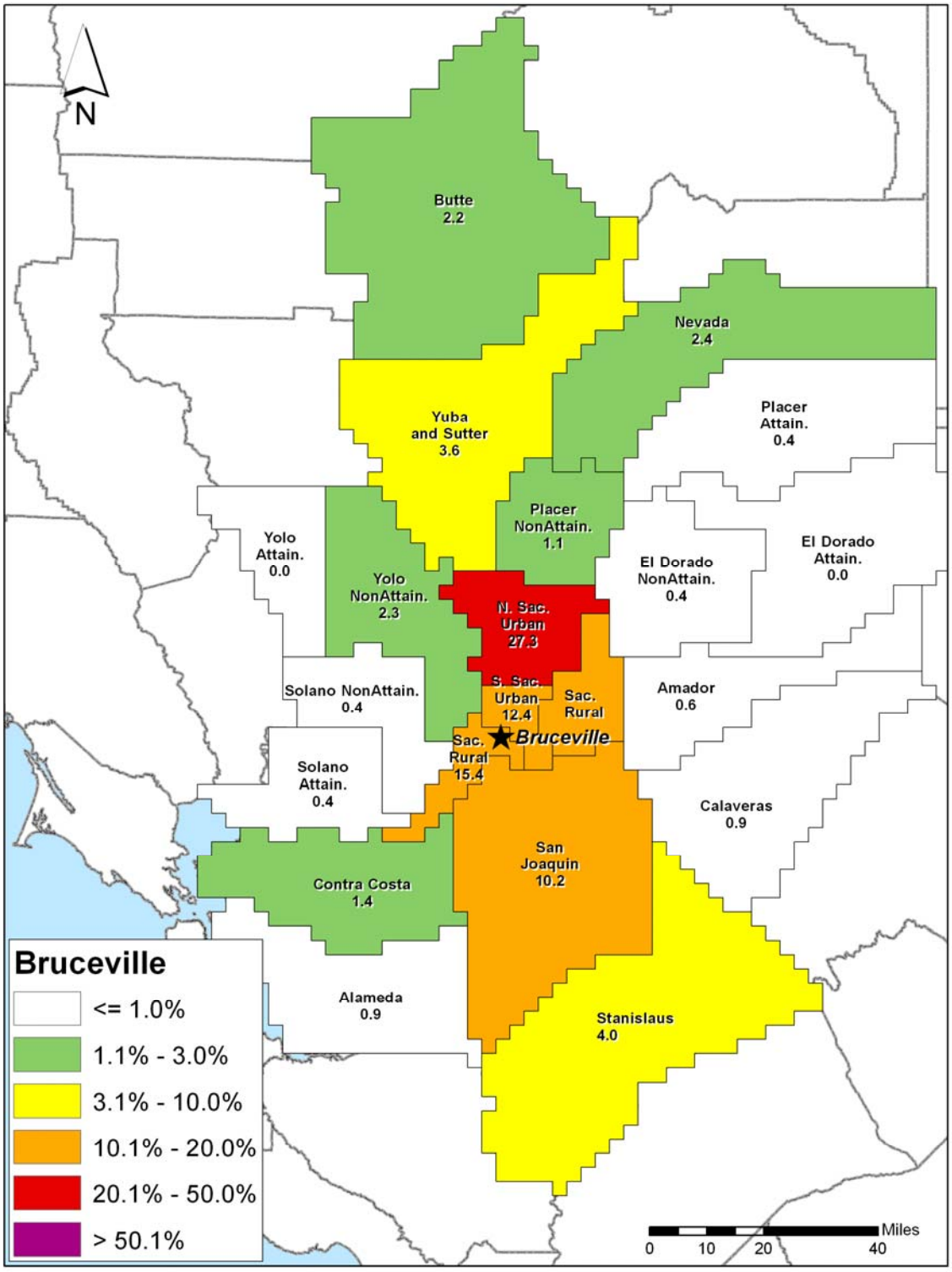

Figure 4-14. Spatial plot of the MM5/CAMx estimated average **percent** contribution from each county or sub-county to Bruceville wood smoke primary $PM_{2.5}$ from December 15, 2000, through January 9, 2001.

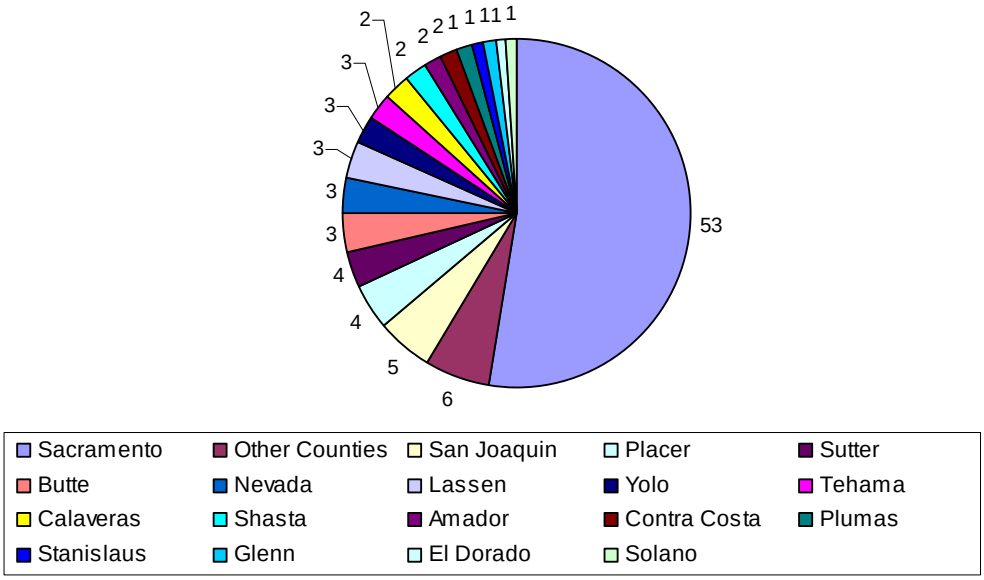

Figure 4-15. TEAK estimated average **percent** contribution from each county to Bruceville wood smoke primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

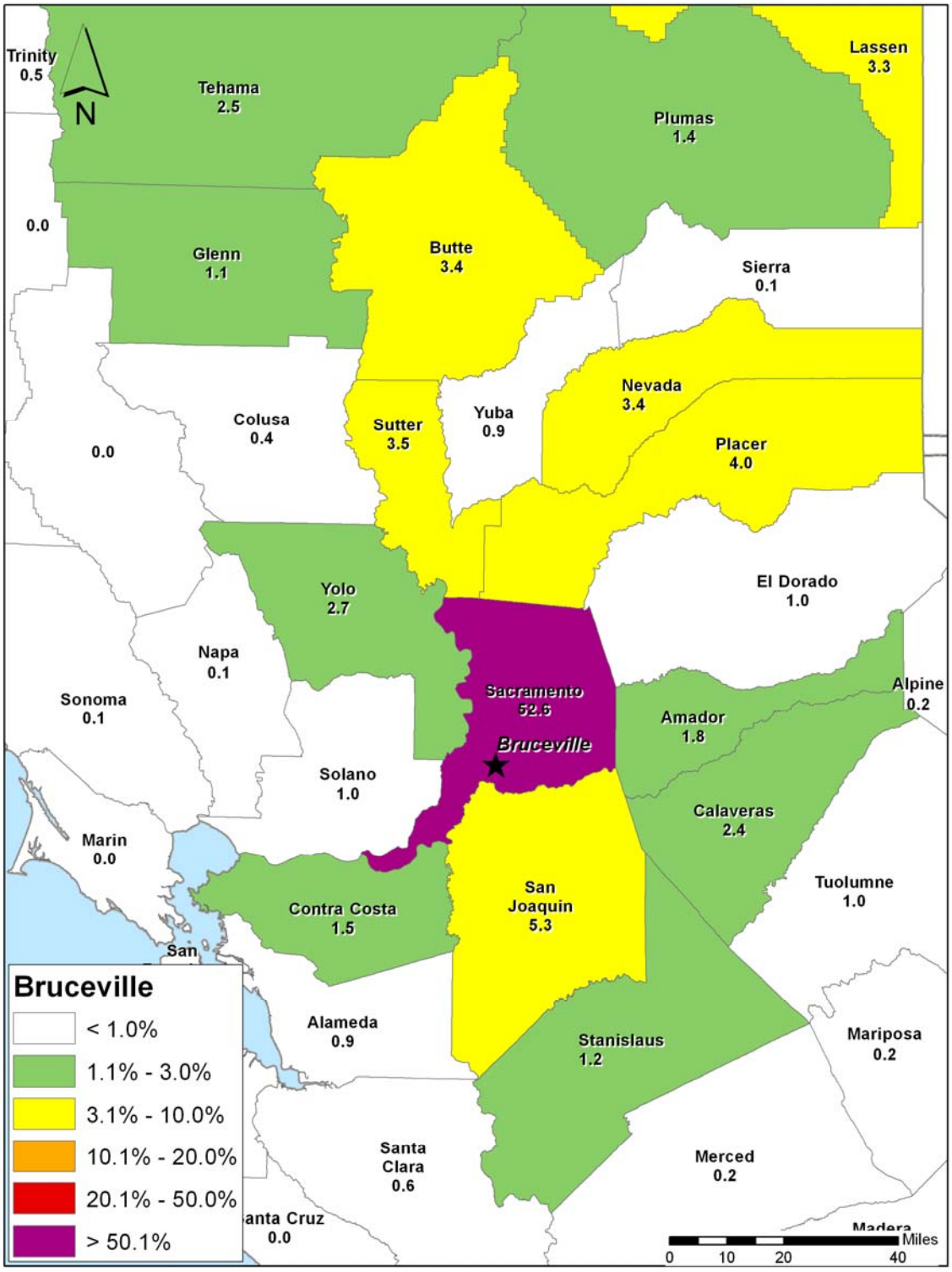

Figure 4-16. Spatial plot of the TEAK estimated average **percent** contribution from each county to Bruceville wood smoke primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009.

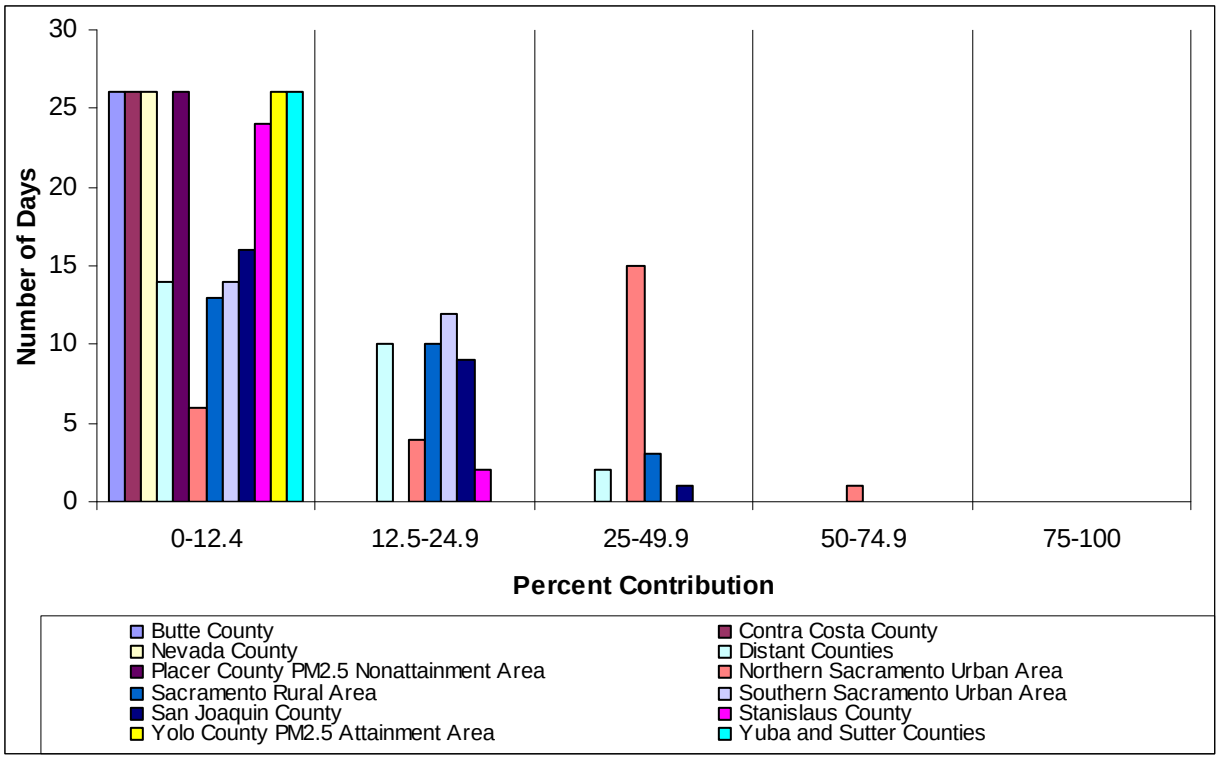

Figure 4-17. MM5/CAMx histogram results showing the number of days within various contribution bins by county for Bruceville for December 15, 2000, through January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

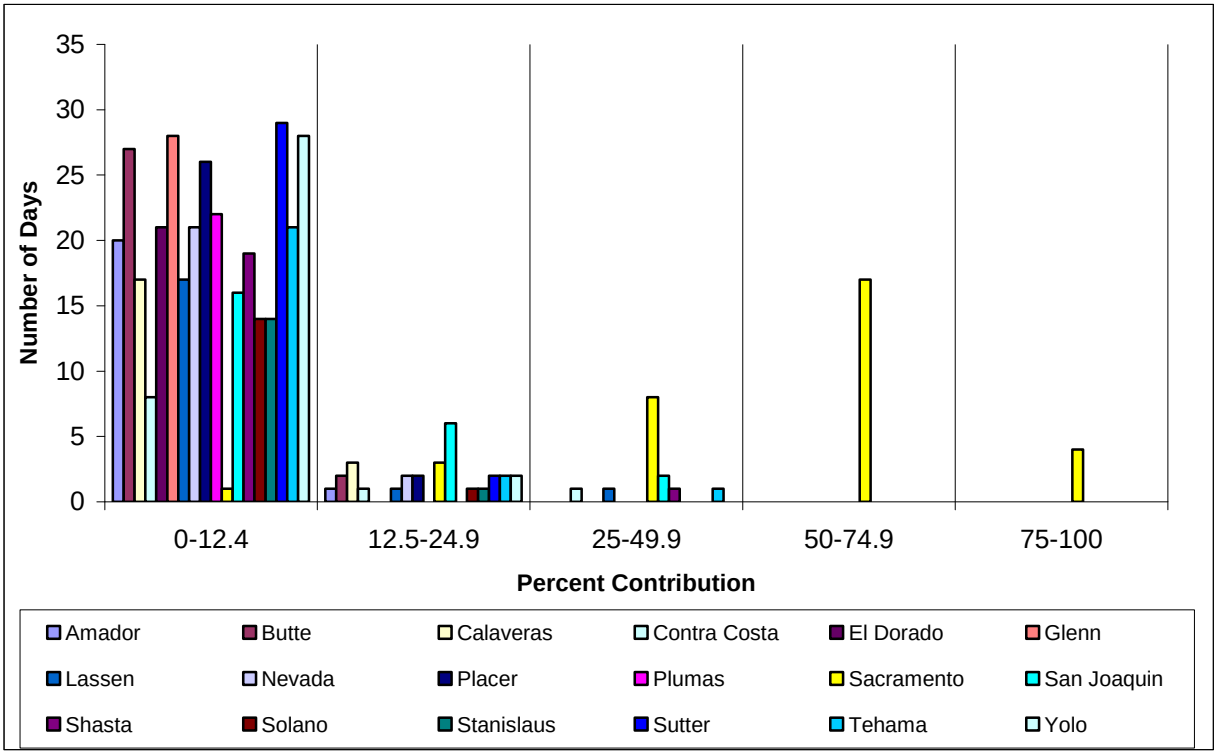

Figure 4-18. TEAK histogram results showing the number of days within various contribution bins by county for Bruceville on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

5. REFERENCES

Air Resources Laboratory (2008) HYSPLIT model. Web page of the National Oceanic and Atmospheric Association, Air Resources Laboratory, Silver Spring, MD. Available on the Internet at <http://www.arl.noaa.gov/ready/hysplit4.html>.

ENVIRON International Corporation (2008) User's guide - Comprehensive Air Quality Model with Extensions (CAMx). Version 4.50. Prepared by ENVIRON International Corporation, Novato, CA, May. Available on the Internet at <http://www.camx.com/files/CAMxUsersGuide_v4.5.pdf>.

MacDonald C.P., Lilly M.A., Roberts P.T., and Richards L.W. (2003) Evaluation of transport of particulate matter and its precursors into and out of the San Joaquin Valley, California: first step, mixing depth. Presented at *American Association for Aerosol Research 2003 Annual Conference, Platform Session 7: California Regional Particulate Air Quality Study, Anaheim, CA, October 22* (STI-902329-2432).

MacDonald C.P., Craig K.J., DeWinter J.L., Pasch A.N., Brown S.G., and Wheeler N.J.M. (2009) Evaluation of Sacramento Metropolitan Air Quality Management District's Check Before You Burn Program. Final report prepared for the Sacramento Metropolitan Air Quality Management District, Sacramento, CA, by Sonoma Technology, Inc., Petaluma, CA, STI-909014.06-3612-FR, May.

Magliano K., Roth P., Blanchard C., Reynolds S., Ziman S., and DeMandel R. (1999) California Regional $PM_{10}/PM_{2.5}$ Air Quality Study: objectives and associated data analysis and modeling approaches. Draft report prepared by California Air Resources Board, Envair, and Bay Area Air Quality Management District, February.

O'Brien J.J. (1970) A note on the vertical structure of the eddy exchange coefficient in the planetary boundary layer. *J. Atmos. Sci.* **27**, 1213-1215.

Wheeler N.J.M., Craig K., and Reid S. (2008) Meteorological modeling analyses of data captured during the CRPAQS field program. Final presentation to the CRPAQS Technical Committee, Sacramento, CA, by Sonoma Technology, Inc., Petaluma, CA, STI-905030-3648, October 1.

Wheeler N.J.M., Reid S., and Craig K. (2005) Status of Meteorological Modeling Analyses of Data Captured During the CRPAQS Field Program. Presentation to the CRPAQS Technical Committee, Sacramento, CA, by Sonoma Technology, Inc., Petaluma, CA, STI-905030, September 12.

APPENDIX A

CONTRIBUTION RESULTS USING THE CURRENT DRAFT INVENTORY

This appendix contains the contribution results in the form of data plots for the Davis, Roseville, and Ranch Seco receptors using the "Current Draft Inventory" for the emissions. Section 4 describes the results for the Del Paso Manor, Folsom, and Bruceville receptors. The results are organized by site and analysis method (MM5/CAMx or TEAK). Only Rancho Seco has MM5/CAMx results. Contributions from individual counties of less than 1% each are summed together and called "Other Counties". Distant counties (i.e., counties outside the 20 counties/sub-counties shown in Table 3-1) were also summed and called "Distant Counties".

Both MM5/CAMx and TEAK modeling methods rely on estimates of residential wood smoke emissions. After these modeling simulations were completed, two sets of updated residential wood smoke emissions data for selected counties were provided by the SMAQMD in the form of county-level scaling factor adjustments to the original inventory used in the modeling. These updated emissions were used to reflect likely changes to the emission inventory by the California Air Resources Board. Because the modeling in this analysis deals only with inert, primary $PM_{2.5}$ emissions, it can be assumed that the absolute wood smoke contribution from a source region is linearly proportional to the emission rate in that source region. Therefore, these scaling factor adjustments were applied to the predicted daily average residential wood smoke $PM_{2.5}$ contributions. The findings presented in the main body of this report and in this appendix are based on the emission scaling factors shown in **Table A-1**, called "Current Draft Inventory". The results presented in Appendix B of this report use the scaling factors shown in **Table A-2,** called "Consistent Inventory Methodology".

Table A-1. Residential wood smoke emission inventory scaling factors called the "Current Draft Inventory".

County	Scale Factor
Sacramento	1.22
El Dorado	0.26
Placer	0.75
Yolo	0.85
Solano	0.75

Table A-2. Residential wood smoke emission inventory scaling factors called the "Consistent Inventory Methodology".

County	Scale Factor
Sacramento	1.22
El Dorado	0.26
Placer	0.85
Yolo	2.71
Solano	2.54

DAVIS

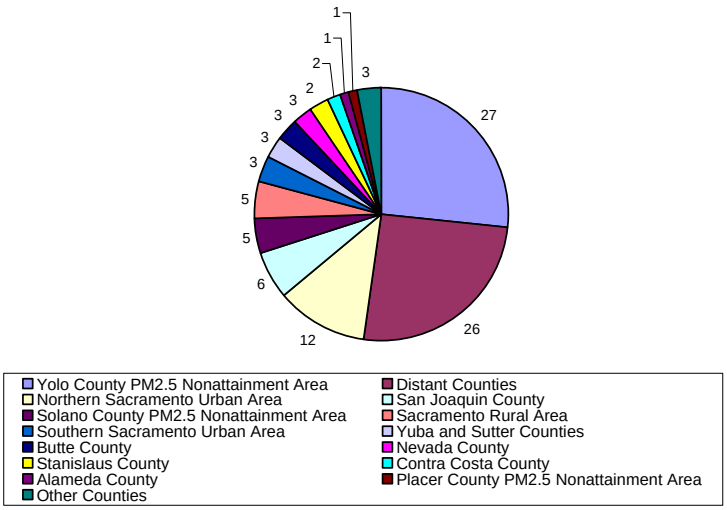

Figure A-1. MM5/CAMx estimated average percent contribution from each county or sub-county to Davis wood smoke primary $PM_{2.5}$ from December 15, 2000, through January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

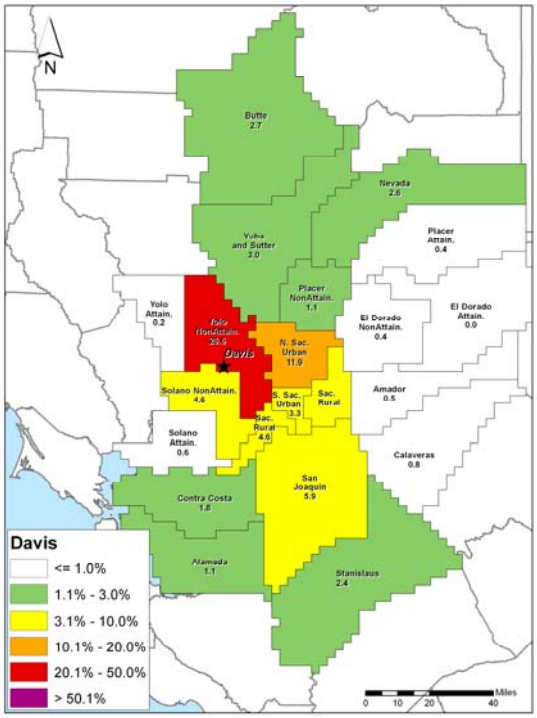

Figure A-2. Spatial plot of the MM5/CAMx estimated average percent contribution from each county or sub-county to Davis wood smoke primary $PM_{2.5}$ from December 15, 2000, through January 9, 2001.

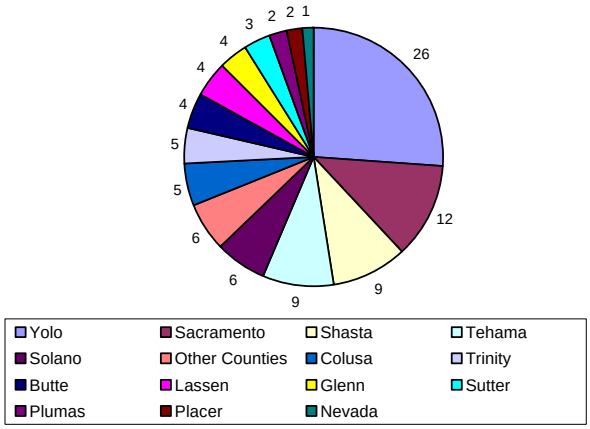

Figure A-3. TEAK estimated average percent contribution from each county to Davis primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations weregreater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

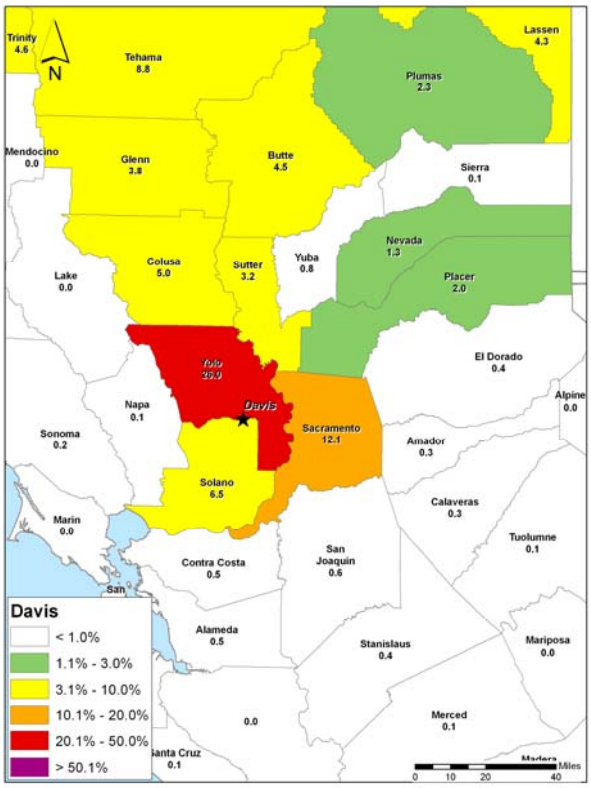

Figure A-4. Spatial plot of the TEAK estimated average percent contribution from each county to Davis wood smoke primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009.

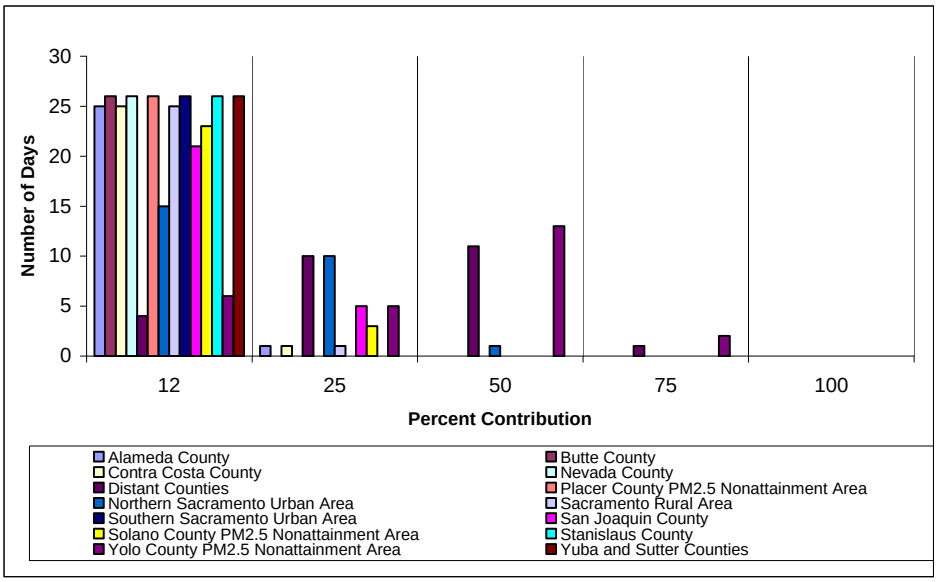

Figure A-5. MM5/CAMx histogram results showing the number of days within various contribution bins by county for Davis from December 15, 2000, through January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

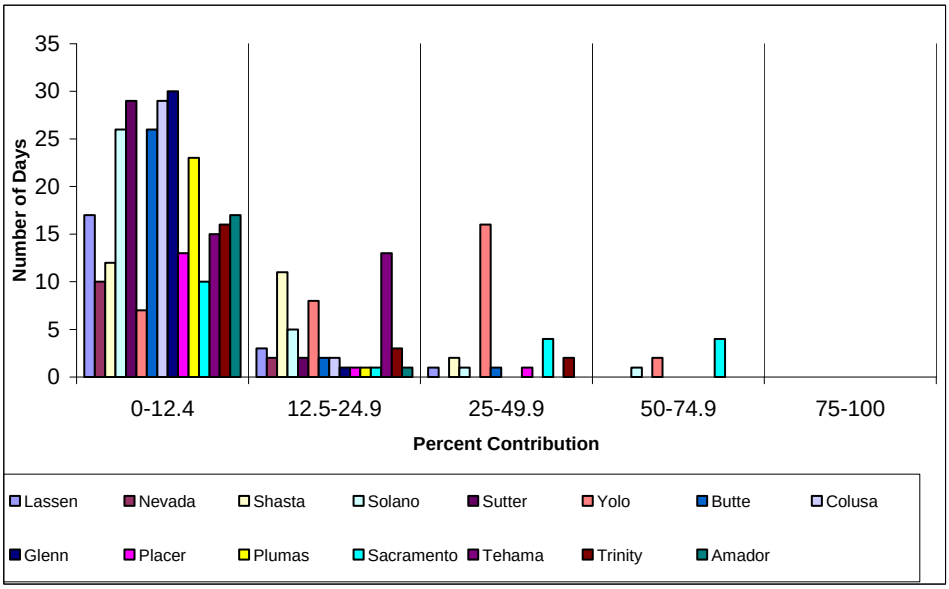

Figure A-6. TEAK histogram results showing the number of days within various contribution bins by county for Davis on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the "winters" of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

ROSEVILLE

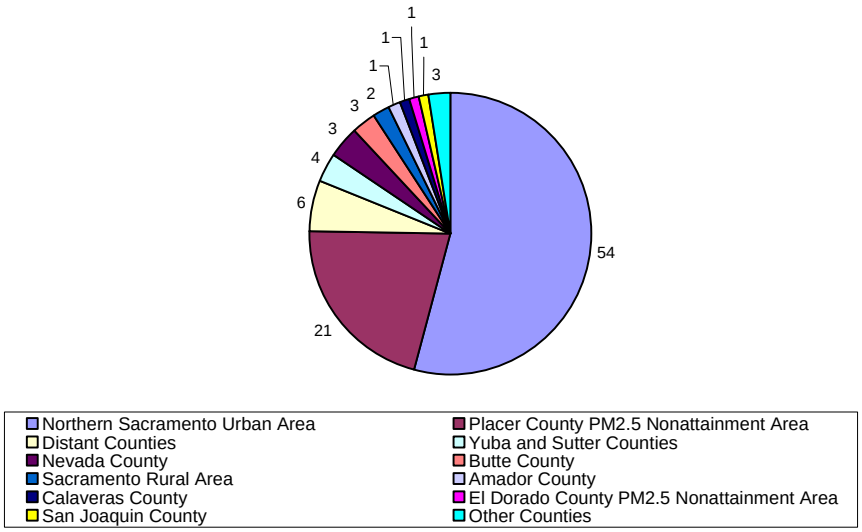

Figure A-7. MM5/CAMx estimated average percent contribution from each county or sub-county to Roseville wood smoke primary $PM_{2.5}$ from December 15, 2000, through January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

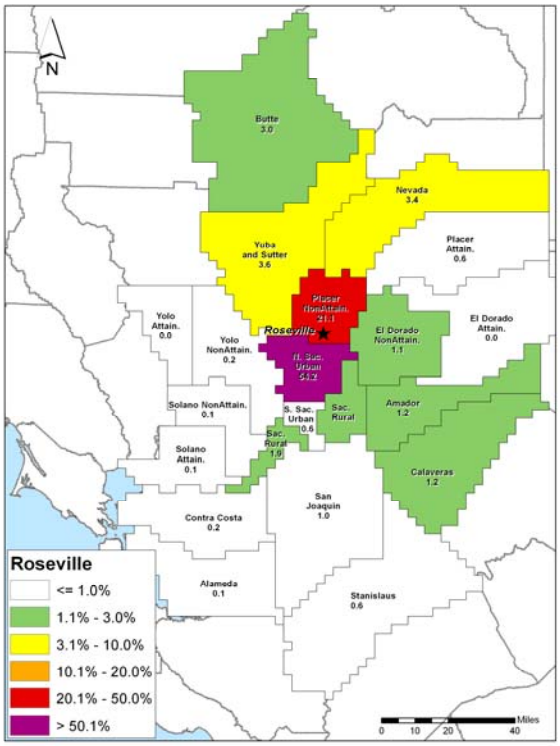

Figure A-8. Spatial plot of the MM5/CAMx estimated average percent contribution from each county or sub-county to Roseville wood smoke primary $PM_{2.5}$ from December 15, 2000, through January 9, 2001.

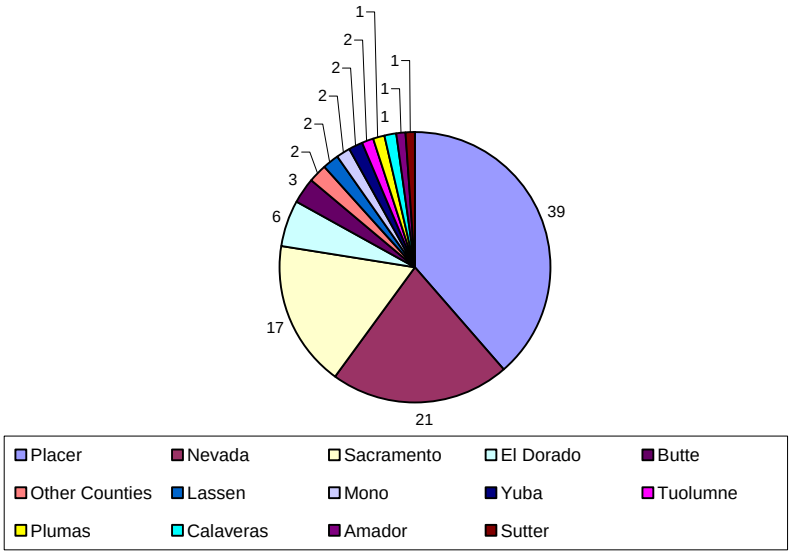

Figure A-9. TEAK estimated average percent contribution from each county to Roseville wood smoke primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

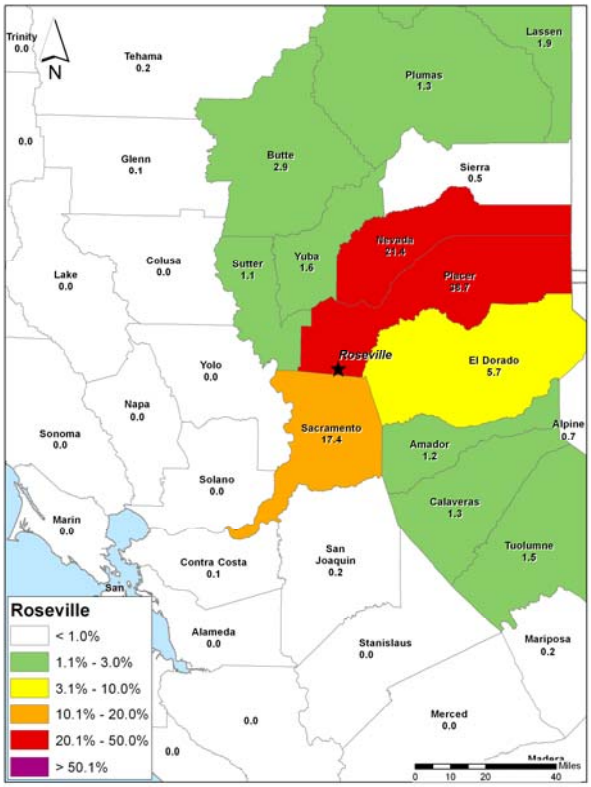

Figure A-10. Spatial plot of the TEAK estimated average percent contribution from each county to Roseville wood smoke primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009.

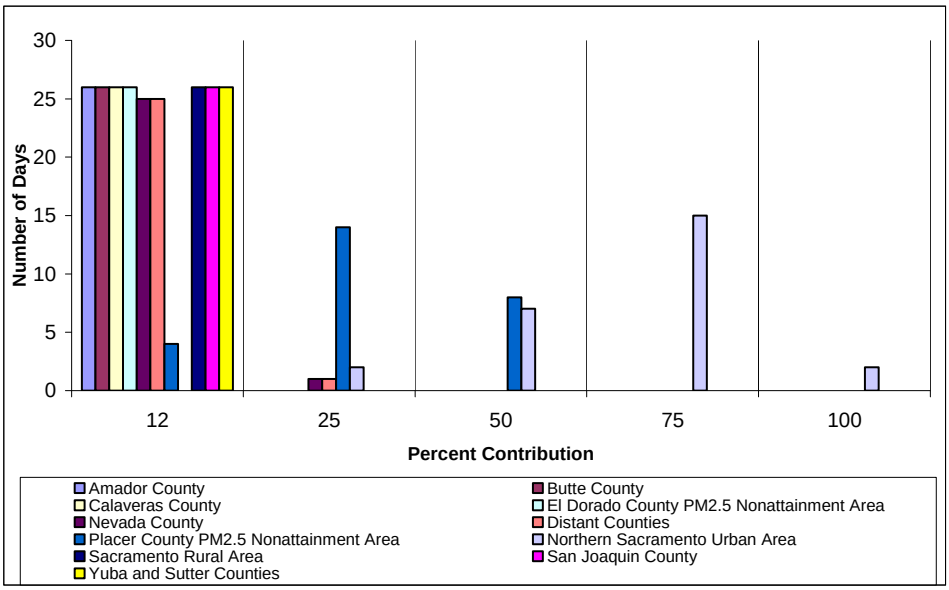

Figure A-11. MM5/CAMx histogram results showing the number of days within various contribution bins by county for Roseville from December 15, 2000, through January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

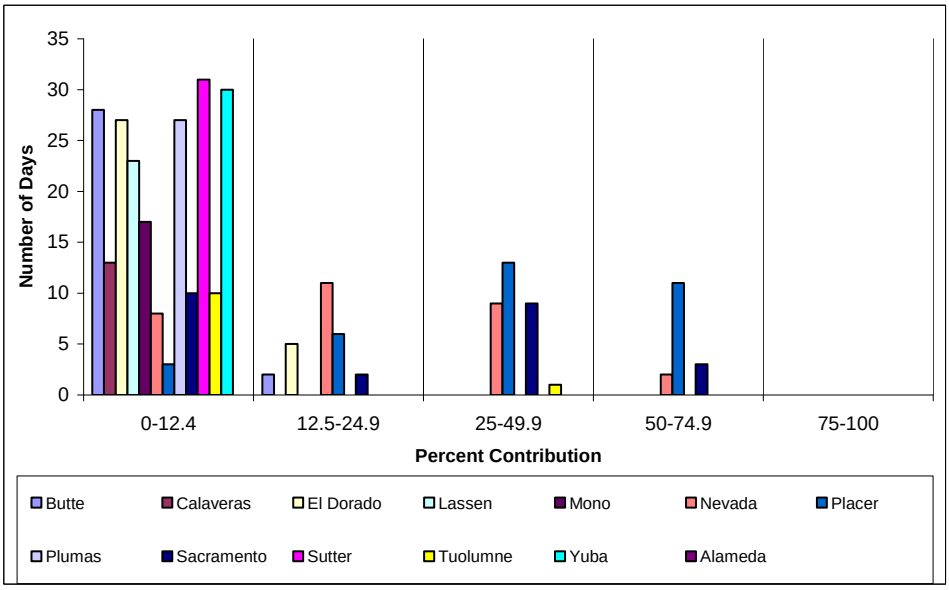

Figure A-12. TEAK histogram results showing the number of days within various contribution bins by county for Roseville on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

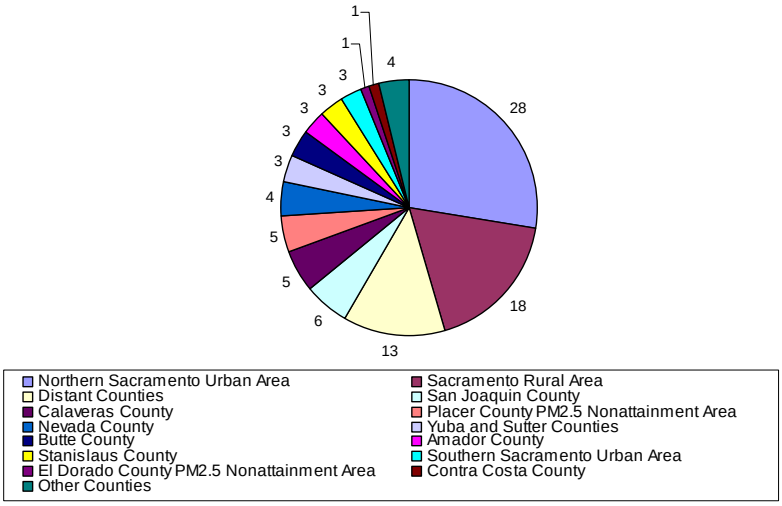

Figure A-13. MM5/CAMx estimated average percent contribution from each county or sub-county to Rancho Seco wood smoke primary $PM_{2.5}$ from December 15, 2000, through January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

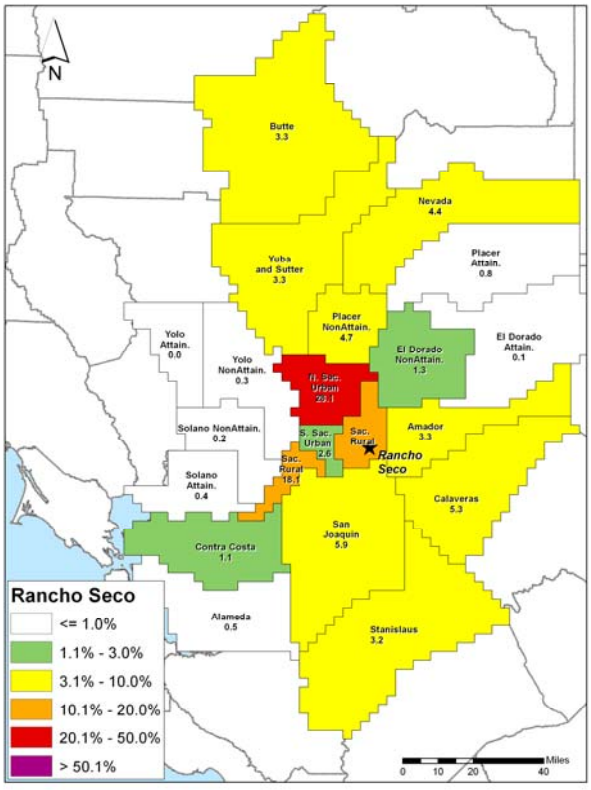

Figure A-14. Spatial plot of the MM5/CAMx estimated average percent contribution from each county or sub-county to Rancho Seco wood smoke primary $PM_{2.5}$ from December 15, 2000, through January 9, 2001.

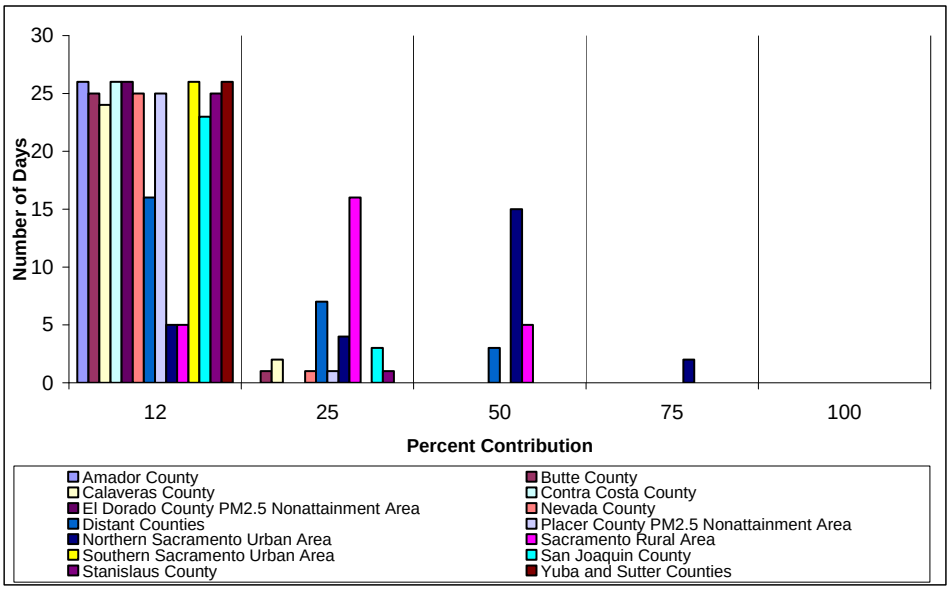

Figure A-15. MM5/CAMx histogram results showing the number of days within various contribution bins by county for Rancho Seco from December 15, 2000, through January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

APPENDIX B

CONTRIBUTION RESULTS USING THE CONSISTENT INVENTORY METHODOLOGY

This appendix contains the contribution results in the form of data plots for the Del Paso Manor, Folsom, Bruceville, Davis, Roseville, and Rancho Seco receptors using the "Consistent Inventory Methodology" for the emissions. The results are organized by site and analysis method (MM5/CAMx or TEAK). Rancho Seco only has MM5/CAMx results. Contributions from individual counties of less than 1% each are summed together and called "Other Counties". Distant counties (i.e., counties that are outside the 20 counties/sub-counties shown in Table 3-1) were also summed and called "Distant Counties".

Both MM5/CAMx and TEAK modeling methods rely on estimates of residential wood smoke emissions. After these modeling simulations were completed, two sets of updated residential wood smoke emissions data for selected counties were provided by the SMAQMD in the form of county-level scaling factor adjustments to the original inventory used in the modeling. These updated emissions were used to reflect likely changes to the emission inventory by the California Air Resources Board. Because the modeling in this analysis deals only with inert, primary $PM_{2.5}$ emissions, it can be assumed that the absolute wood smoke contribution from a source region is linearly proportional to the emission rate in that source region. Therefore, these scaling factor adjustments were applied to the predicted daily average residential wood smoke $PM_{2.5}$ contributions. The findings presented in the main body of this report are based on the emission scaling factors, called "Current Draft Inventory", shown in **Table B-1**. The results presented in this Appendix use the scaling factors, called "Consistent Inventory Methodology", shown in **Table B-2**.

Table B-1. Residential wood smoke emission inventory scaling factors called the "Current Draft Inventory".

County	Scale Factor
Sacramento	1.22
El Dorado	0.26
Placer	0.75
Yolo	0.85
Solano	0.75

Table B-2. Residential wood smoke emission inventory scaling factors called the "Consistent Inventory Methodology".

County	Scale Factor
Sacramento	1.22
El Dorado	0.26
Placer	0.85
Yolo	2.71
Solano	2.54

DEL PASO MANOR

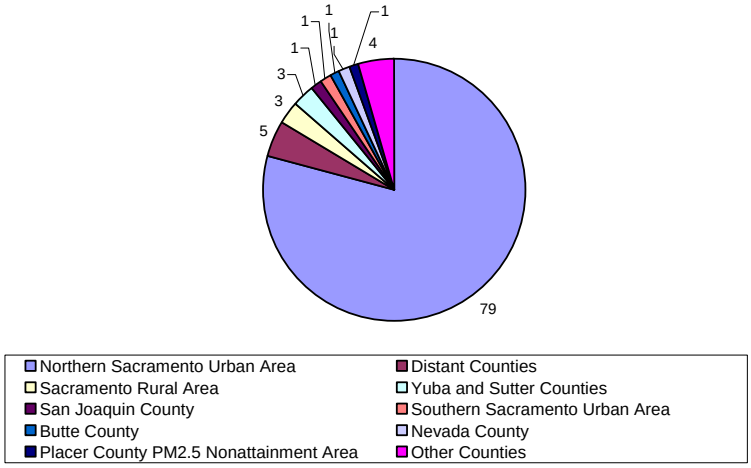

Figure B-1. MM5/CAMx estimated average percent contribution from each county or sub-county to Del Paso Manor primary $PM_{2.5}$ during December 15, 2000–January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

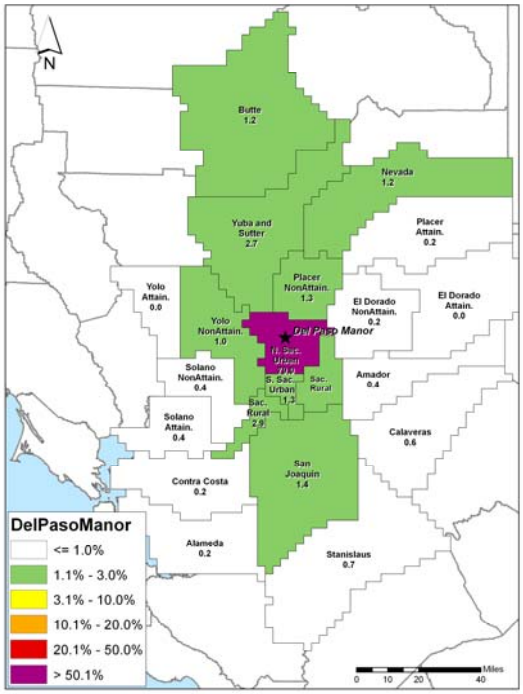

Figure B-2. Spatial plot of the MM5/CAMx estimated average percent contribution from each county or sub-county to Del Paso Manor primary $PM_{2.5}$ during December 15, 2000–January 9, 2001.

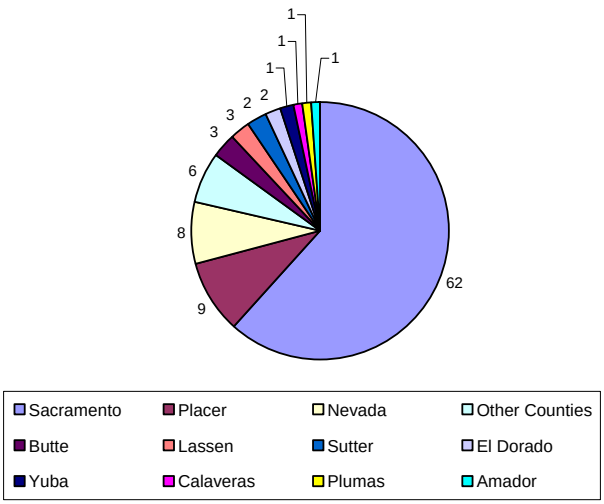

Figure B-3. TEAK estimated average percent contribution from each county to Del Paso Manor primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

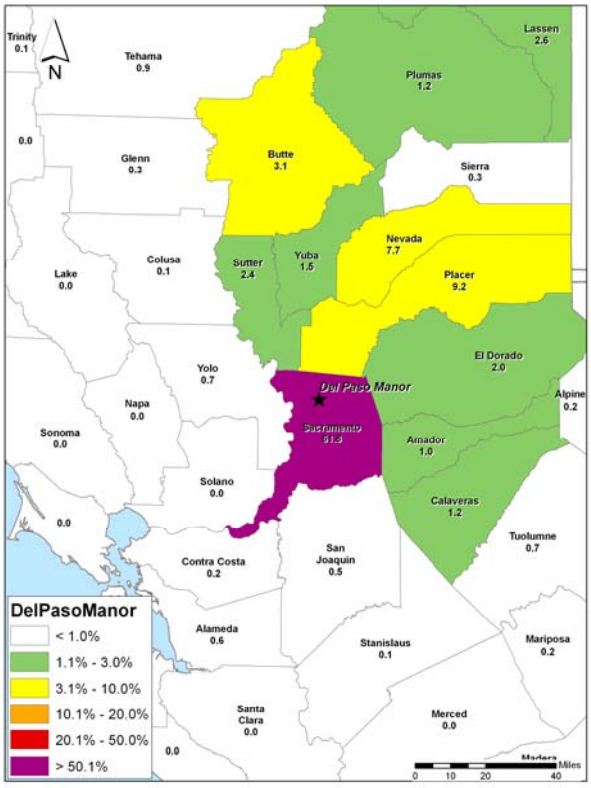

Figure B-4. Spatial plot of the TEAK estimated average percent contribution from each county to Del Paso Manor primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009.

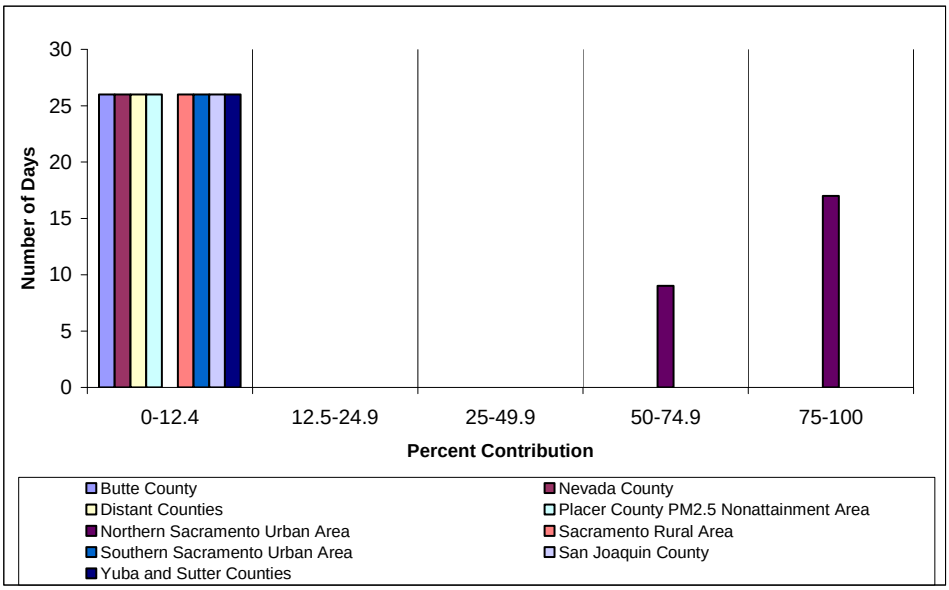

Figure B-5. MM5/CAMx histogram results showing the number of days within various contribution bins by county for Del Paso Manor for December 15, 2000–January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

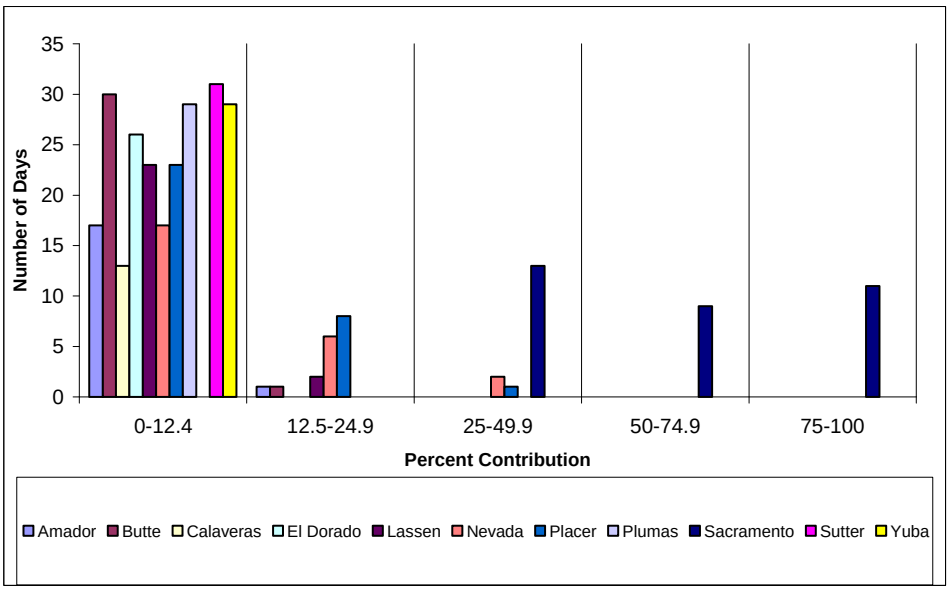

Figure B-6. TEAK histogram results showing the number of days within various contribution bins by county for Del Paso Manor on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

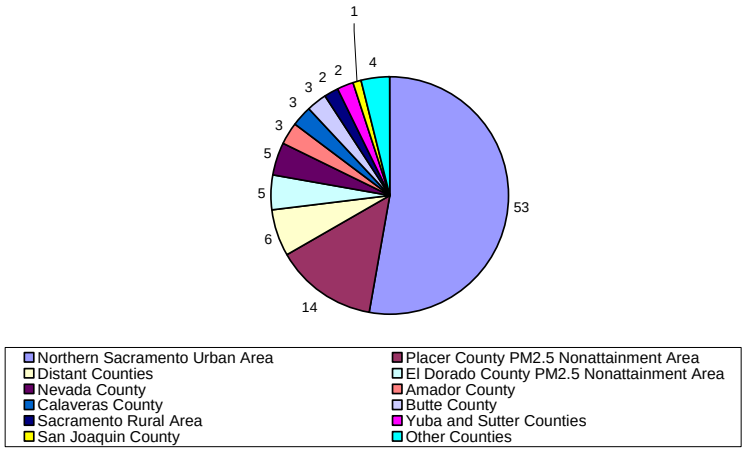

Figure B-7. MM5/CAMx estimated average percent contribution from each county or sub-county to Folsom primary $PM_{2.5}$ during December 15, 2000–January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

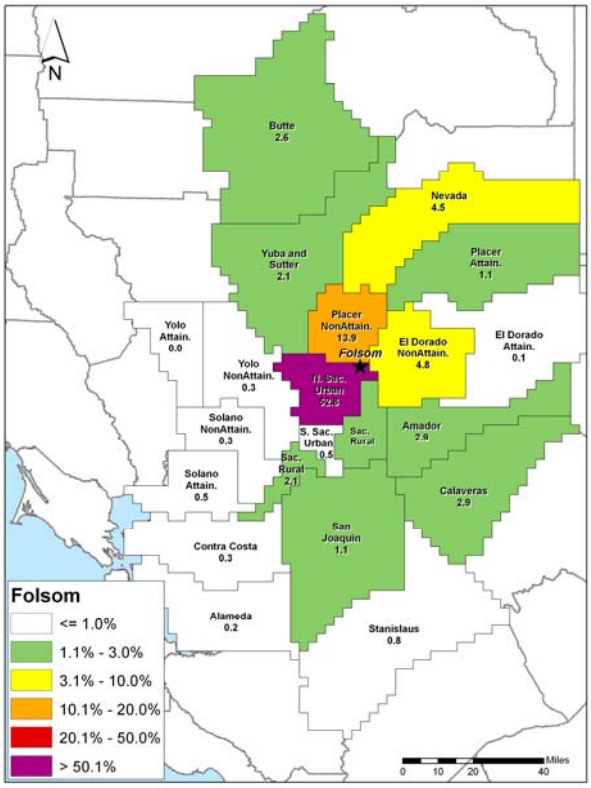

Figure B-8. Spatial plot of the MM5/CAMx estimated average percent contribution from each county or sub-county to Folsom primary $PM_{2.5}$ during December 15, 2000–January 9, 2001.

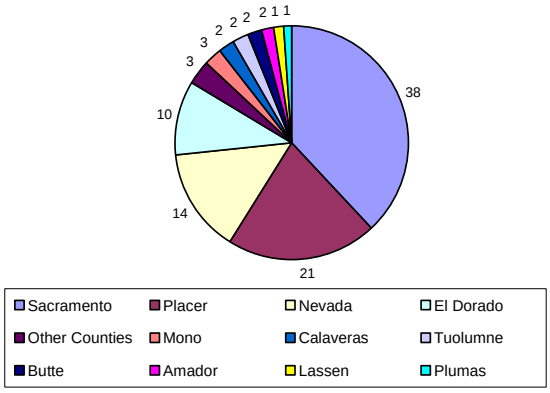

Figure B-9. TEAK estimated average percent contribution from each county to Folsom primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 $\mu g/m^3$ in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

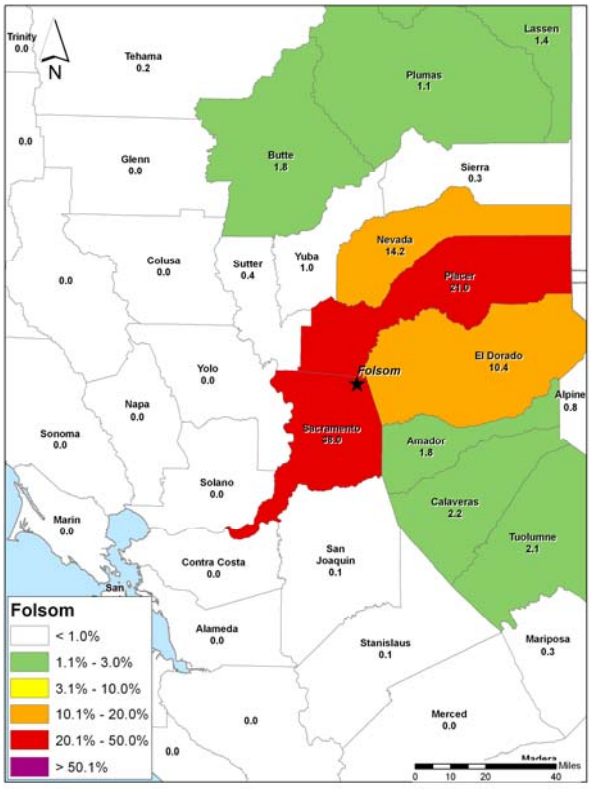

Figure B-10. Spatial plot of the TEAK estimated average percent contribution from each county to Folsom primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 $\mu g/m^3$ in Sacramento County during the winters of 2007/2008 and 2008/2009.

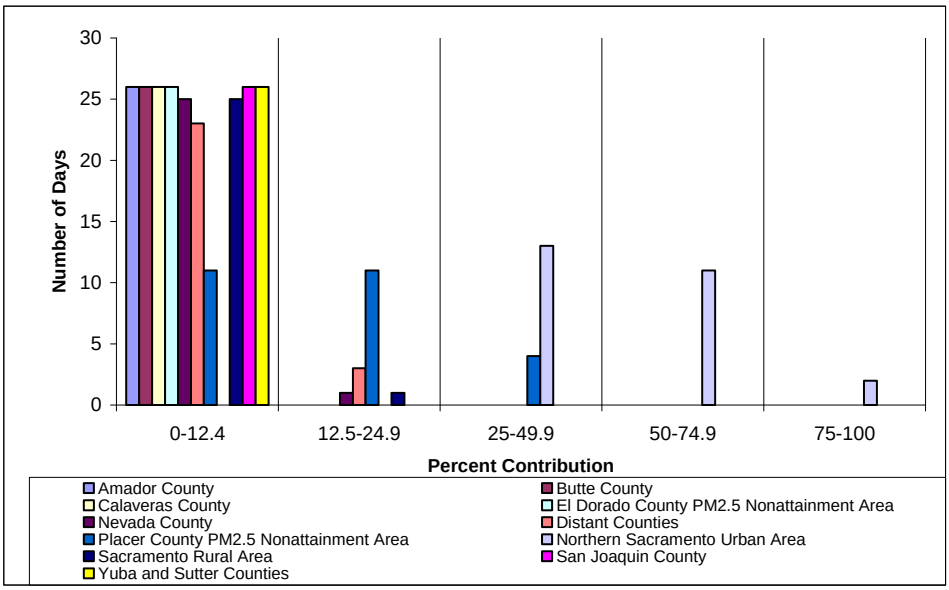

Figure B-11. MM5/CAMx histogram results showing the number of days within various contribution bins by county for Folsom for December 15, 2000–January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

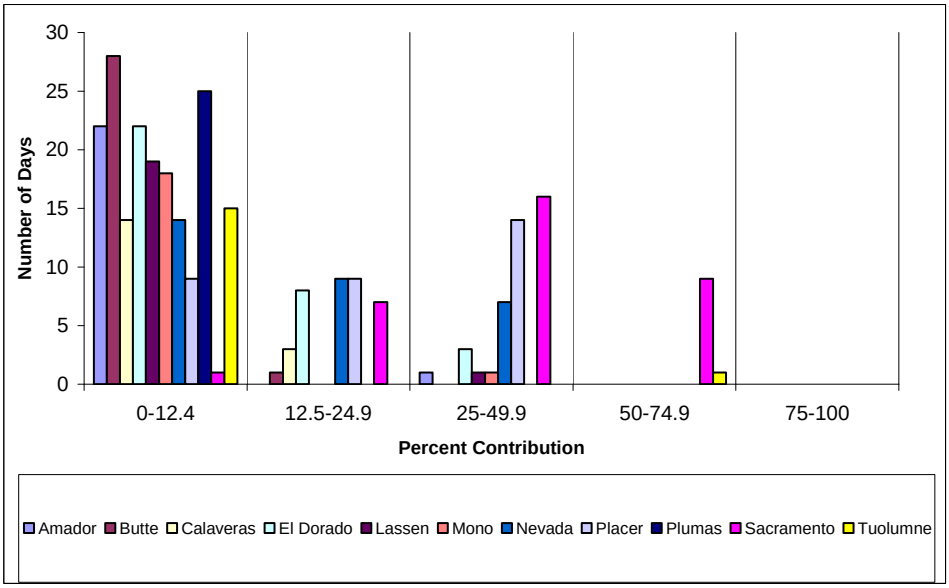

Figure B-12. TEAK histogram results showing the number of days within various contribution bins by county for Folsom on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

BRUCEVILLE

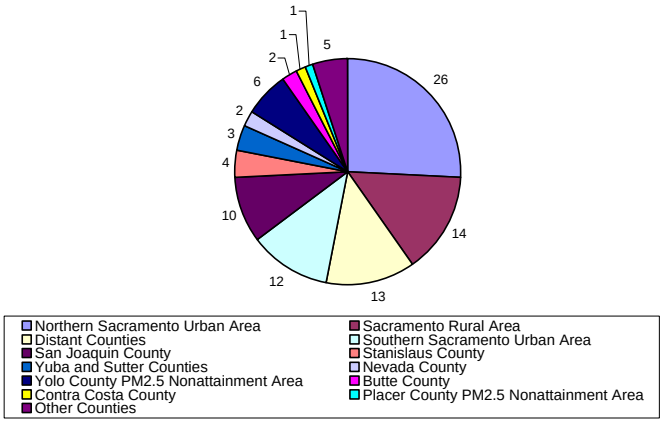

Figure B-13. MM5/CAMx estimated average percent contribution from each county or sub-county to Bruceville primary $PM_{2.5}$ during December 15, 2000–January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

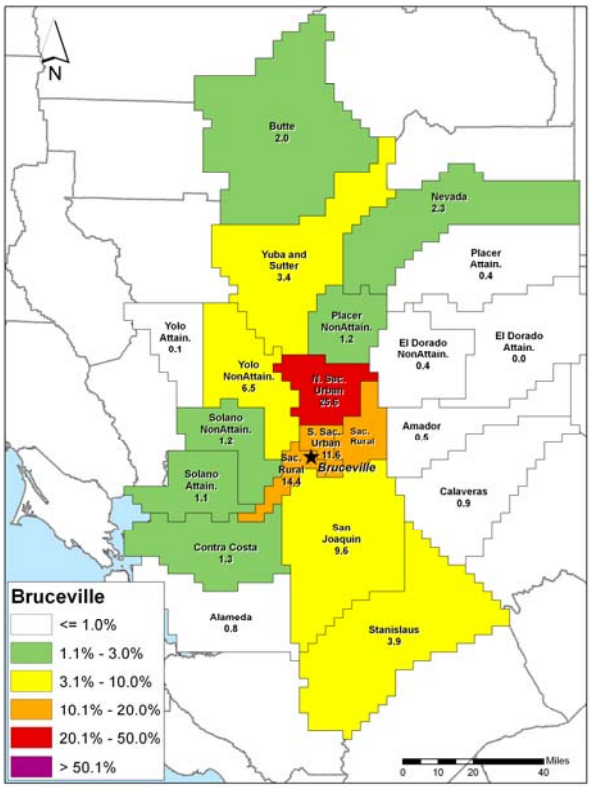

Figure B-14. Spatial plot of the MM5/CAMx estimated average percent contribution from each county or sub-county to Bruceville primary $PM_{2.5}$ during December 15, 2000–January 9, 2001.

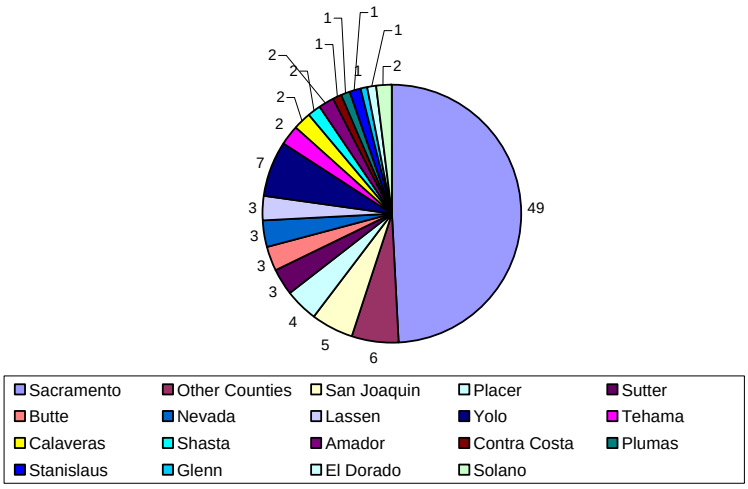

Figure B-15. TEAK estimated average percent contribution from each county to Bruceville primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

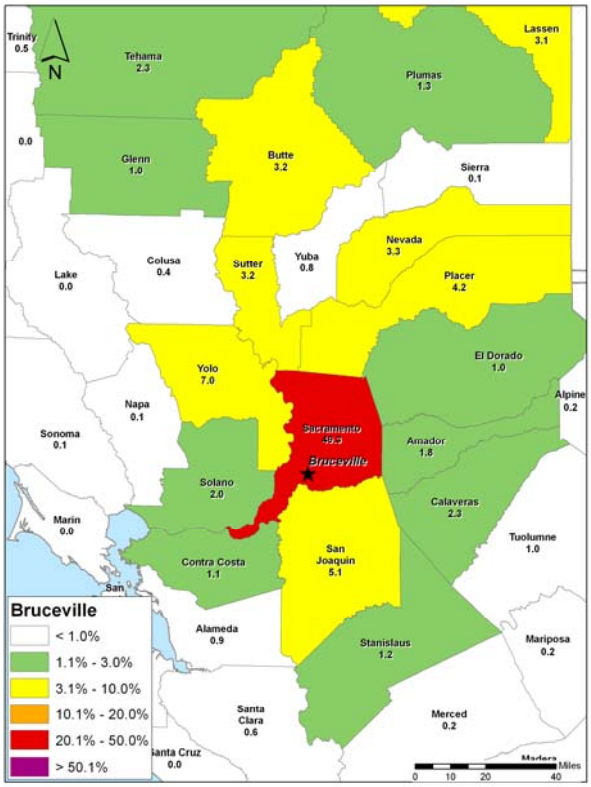

Figure B-16. Spatial plot of the TEAK estimated average percent contribution from each county to Bruceville primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009.

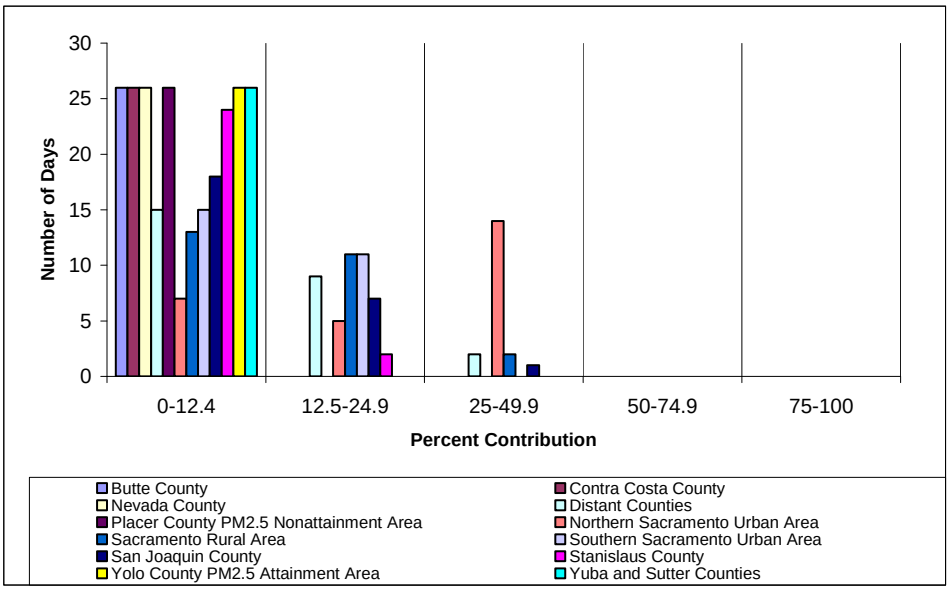

Figure B–17. MM5/CAMx histogram results showing the number of days within various contribution bins by county for Bruceville for December 15, 2000–January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

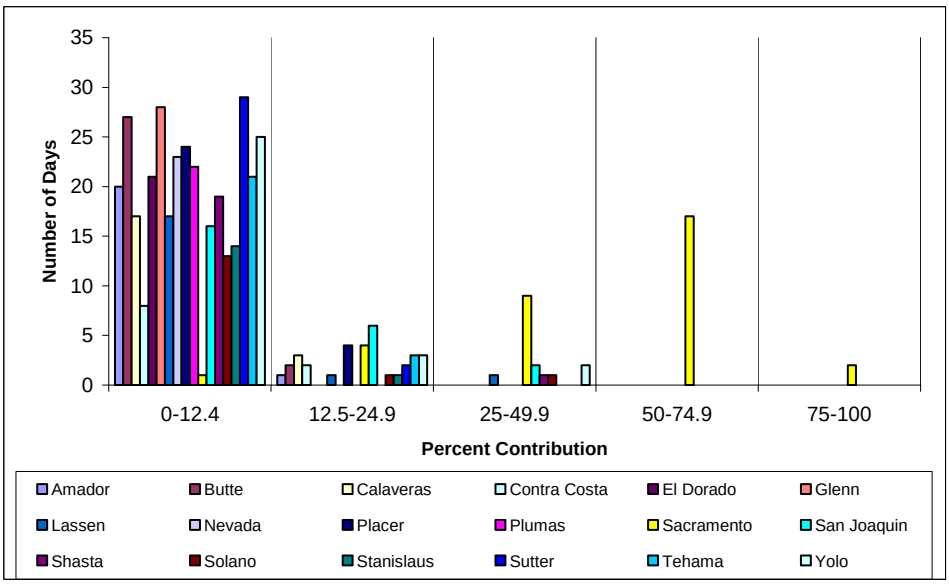

Figure B–18. TEAK histogram results showing the number of days within various contribution bins by county for Bruceville on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

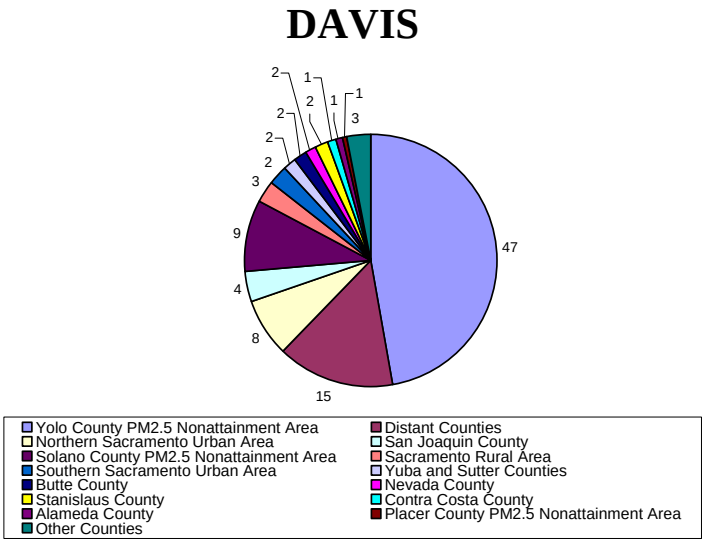

Figure B–19. MM5/CAMx estimated average percent contribution from each county or sub-county to Davis primary $PM_{2.5}$ during December 15, 2000–January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

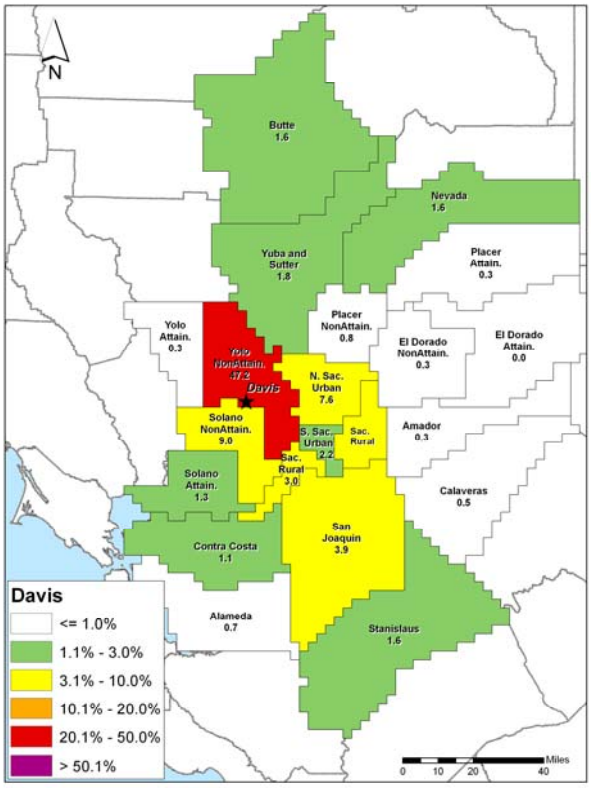

Figure B–20. Spatial plot of the MM5/CAMx estimated average percent contribution from each county or sub-county to Davis primary $PM_{2.5}$ during December 15, 2000–January 9, 2001.

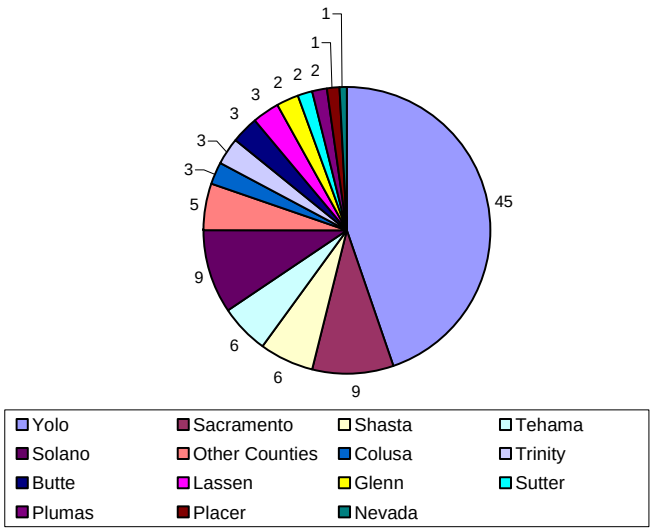

Figure B–21. TEAK estimated average percent contribution from each county to Davis primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

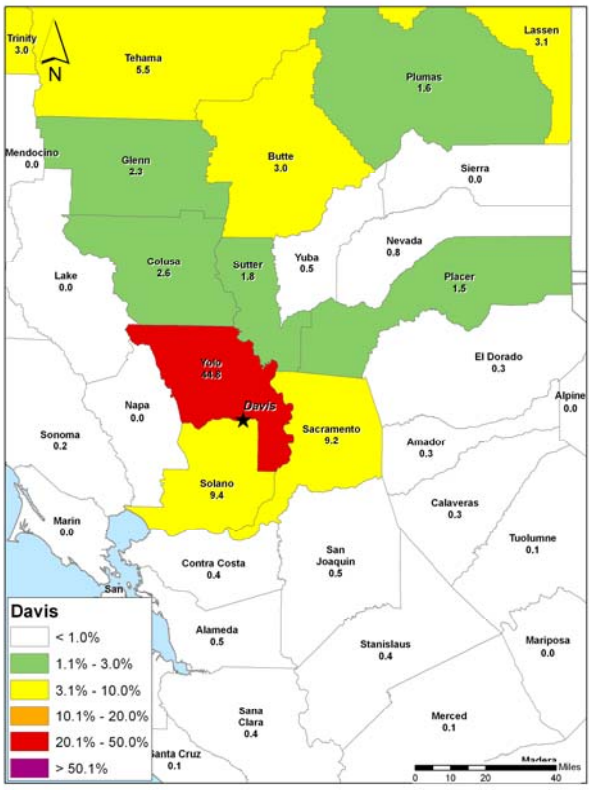

Figure B–22. Spatial plot of the TEAK estimated average percent contribution from each county to Davis primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009.

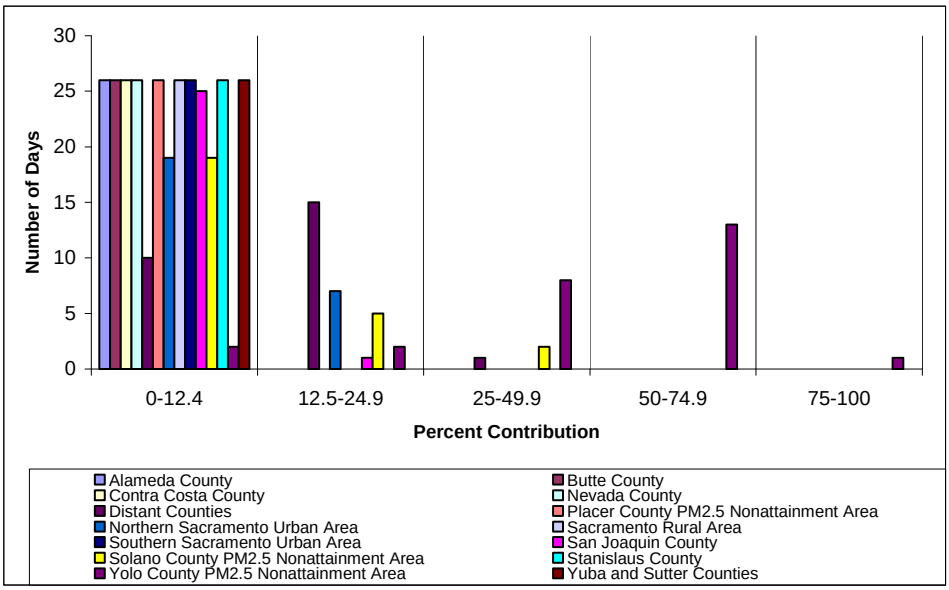

Figure B–23. MM5/CAMx histogram results showing the number of days within various contribution bins by county for Davis for December 15, 2000–January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

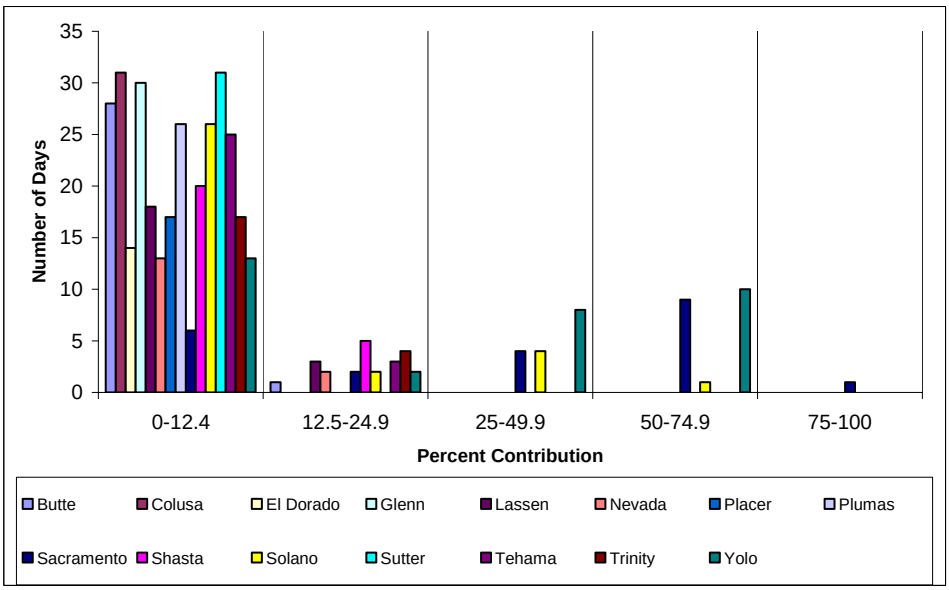

Figure B–24. TEAK histogram results showing the number of days within various contribution bins by county for Davis on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 $\mu g/m^3$ in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

ROSEVILLE

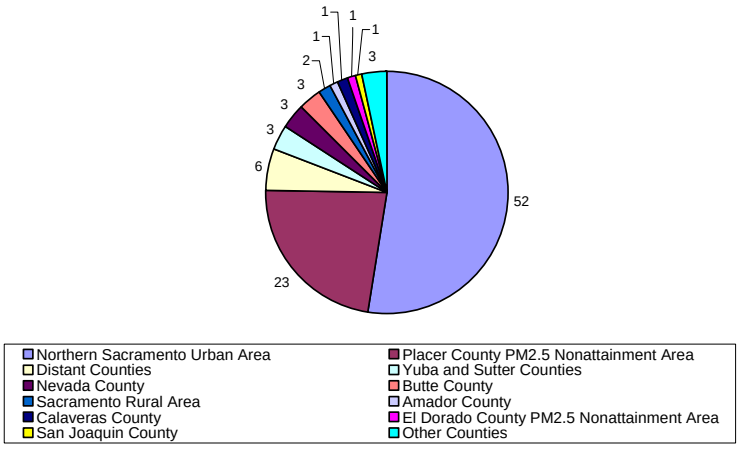

Figure B–25. MM5/CAMx estimated average percent contribution from each county or sub-county to Roseville primary $PM_{2.5}$ during December 15, 2000–January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

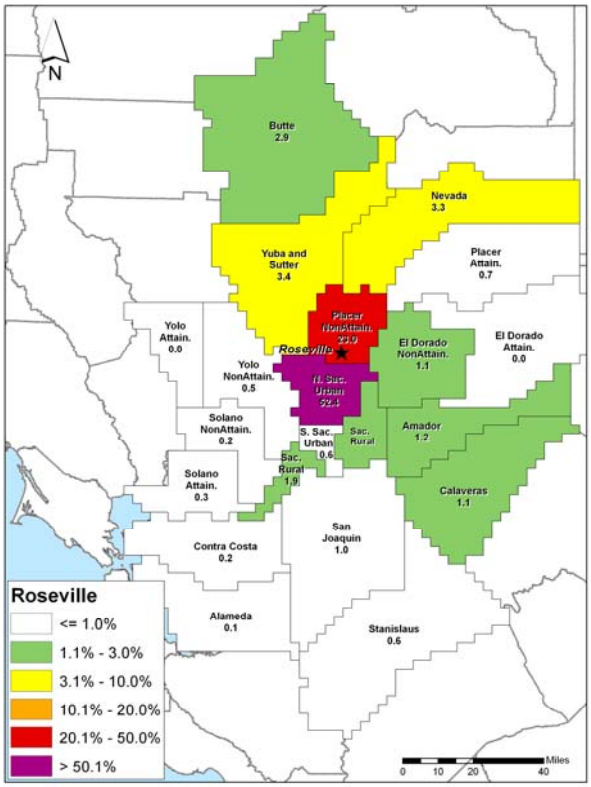

Figure B–26. Spatial plot of the MM5/CAMx estimated average percent contribution from each county or sub-county to Roseville primary $PM_{2.5}$ during December 15, 2000–January 9, 2001.

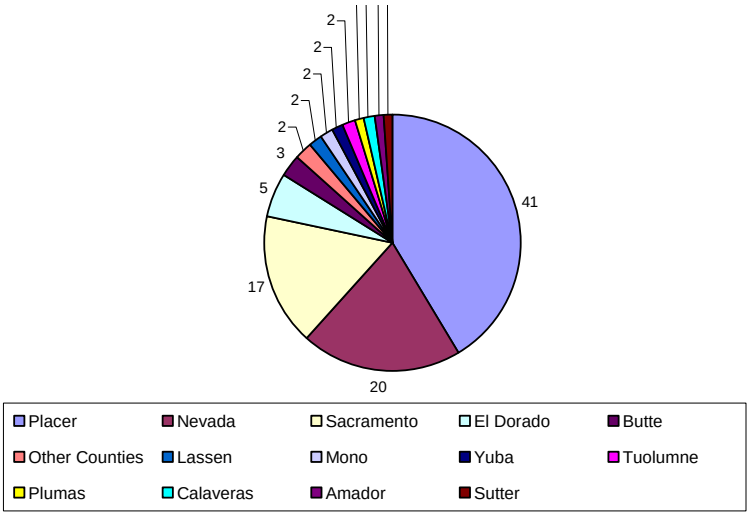

Figure B–27. TEAK estimated average percent contribution from each county to Roseville primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

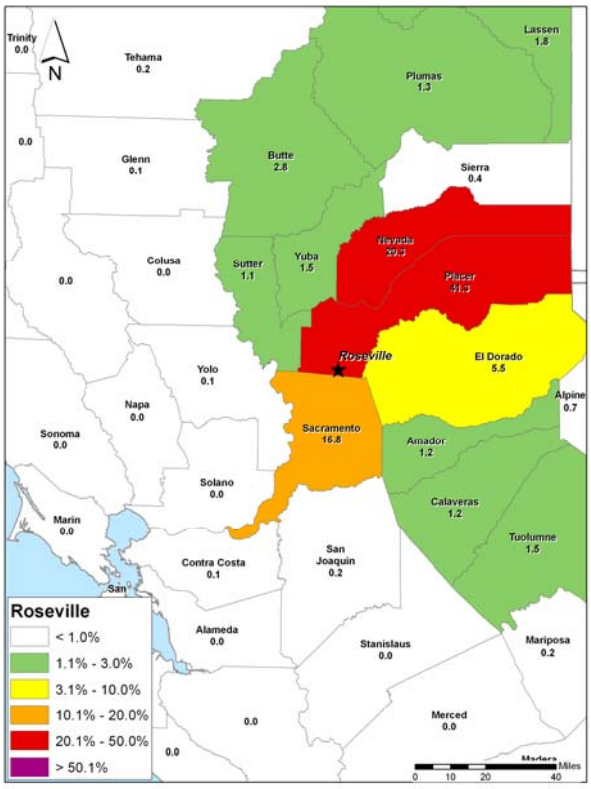

Figure B–28. Spatial plot of the TEAK estimated average percent contribution from each county to Roseville primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009.

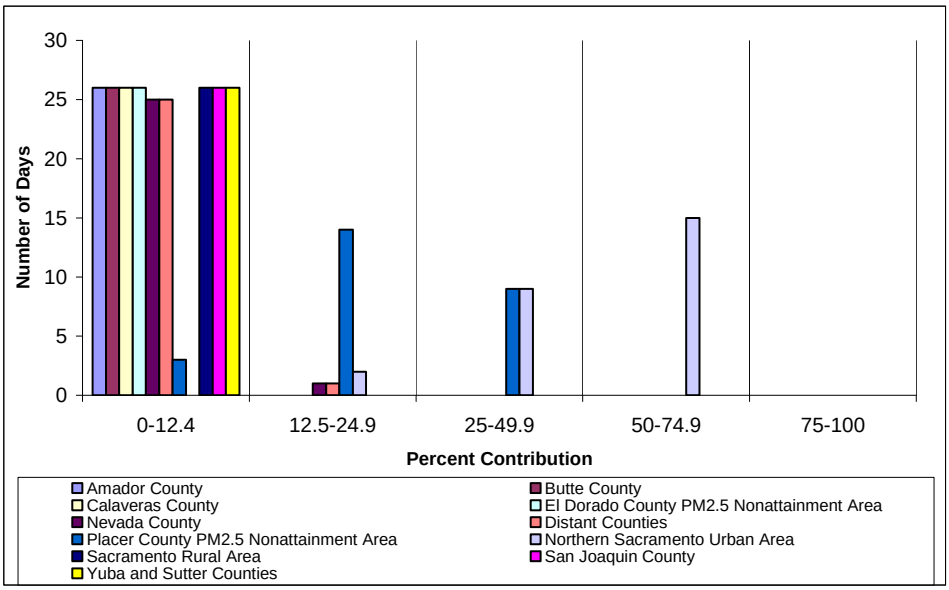

Figure B–29. MM5/CAMx histogram results showing the number of days within various contribution bins by county for Roseville for December 15, 2000–January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

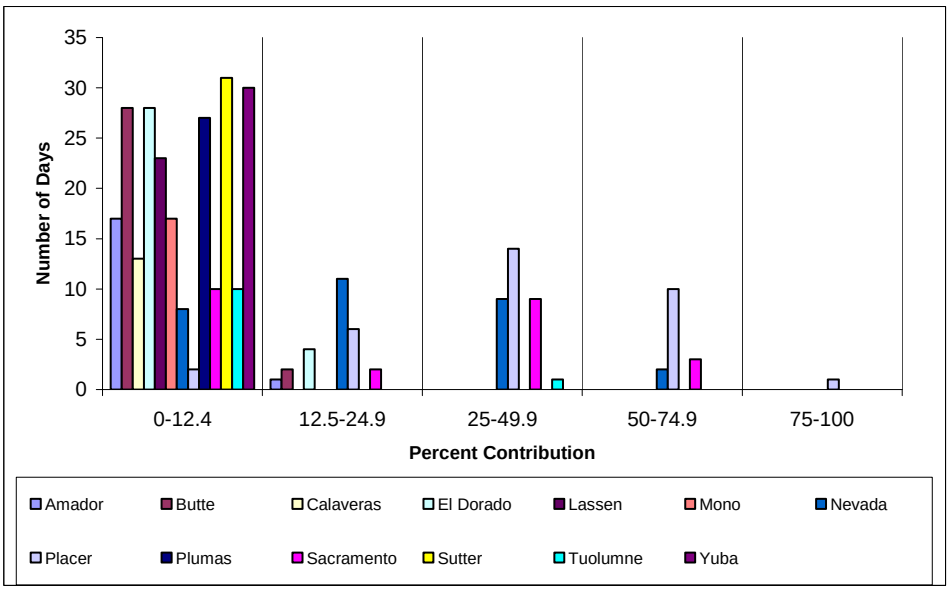

Figure B–30. TEAK histogram results showing the number of days within various contribution bins by county for Roseville on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 in Sacramento County during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

RANCHO SECO

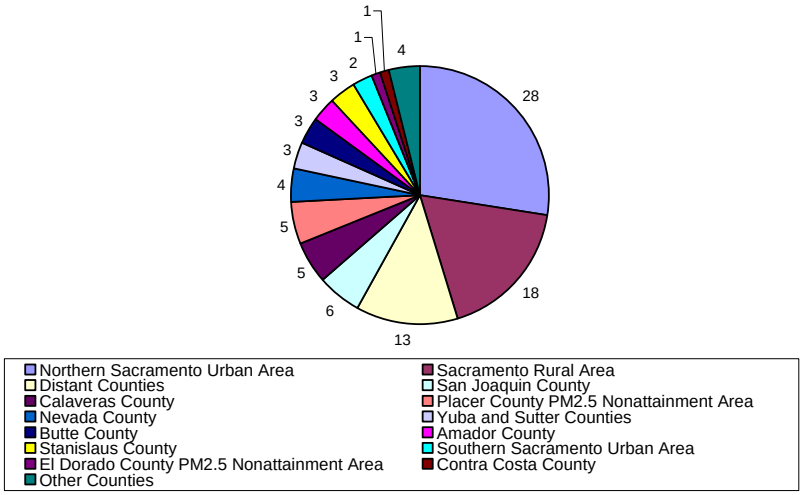

Figure B–31. MM5/CAMx estimated average percent contribution from each county or sub-county to Rancho Seco primary $PM_{2.5}$ during December 15, 2000–January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

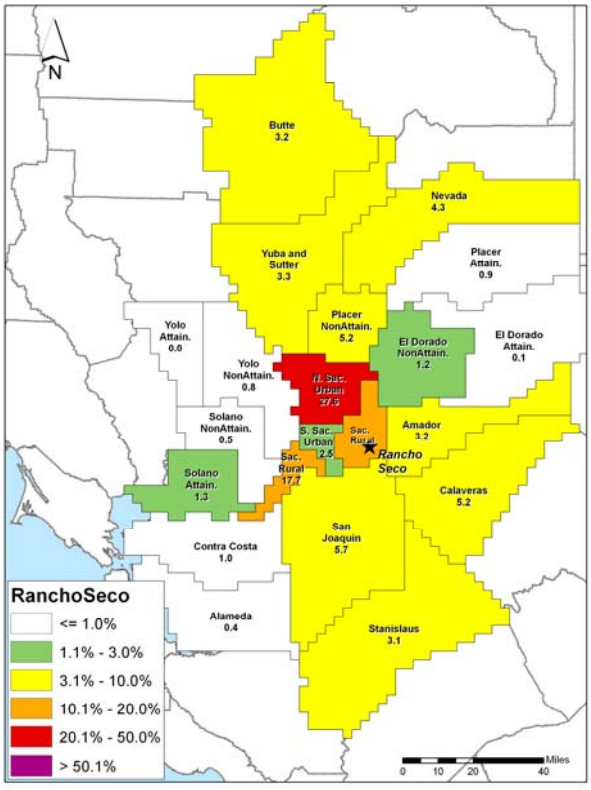

Figure B–32. Spatial plot of the MM5/CAMx estimated average percent contribution from each county or sub-county to Rancho Seco primary $PM_{2.5}$ during December 15, 2000–January 9, 2001.

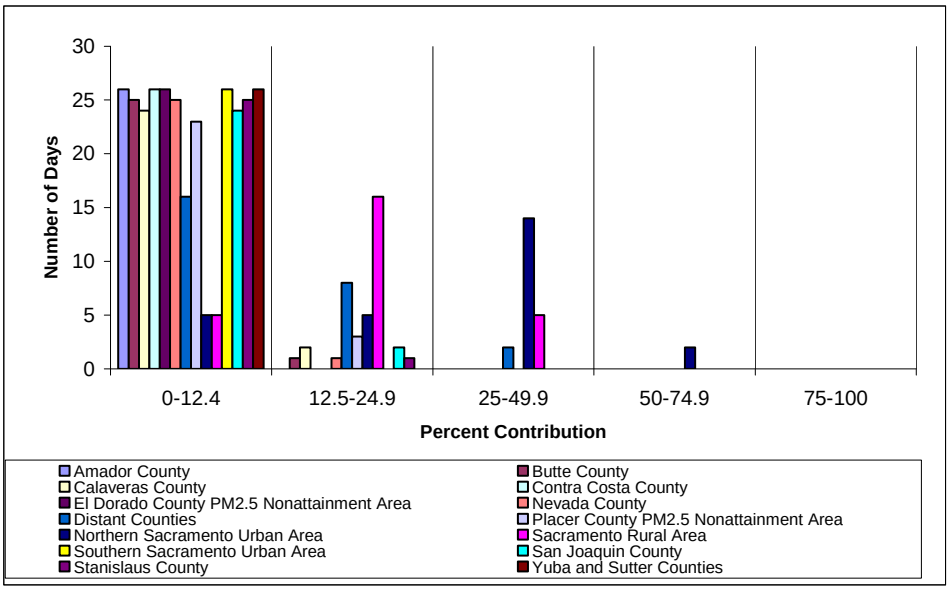

Figure B–33. MM5/CAMx histogram results showing the number of days within various contribution bins by county for Rancho Seco for December 15, 2000–January 9, 2001. Only counties or sub-counties with contributions greater than 1% are shown individually.

APPENDIX C

TEAK CONTRIBUTION RESULTS USING THE CONSISTENT INVENTORY METHODOLOGY FOR HIGH $PM_{2.5}$ DAYS BY SITE

This appendix contains the TEAK estimated average percent contribution in the form of data plots for the Del Paso Manor, Folsom, Bruceville, Davis, and Roseville receptors for the winters of 2007/2008 and 2008/2009 using the "Consistent Inventory Methodology" for the emissions. For each receptor, daily contributions were only included in the average if the observed 24-hr $PM_{2.5}$ concentrations were greater than 35.5 $\mu g/m^3$ at a given receptor. Contributions of less than 1% each from individual counties are summed together and called "Other Counties". Distant counties (i.e., counties that are outside the 20 counties/sub-counties shown in Table 3-1) were also summed and called "Distant Counties".

The TEAK modeling method relies on estimates of residential wood smoke emissions. After the modeling simulations were completed, two sets of updated residential wood smoke emissions data for selected counties were provided by the SMAQMD in the form of county-level scaling factor adjustments to the original inventory used in the modeling. These updated emissions were used to reflect likely changes to the emission inventory by the California Air Resources Board. Because the modeling in this analysis deals only with inert, primary $PM_{2.5}$ emissions, it can be assumed that the absolute wood smoke contribution from a source region is linearly proportional to the emission rate in that source region. Therefore, these scaling factor adjustments were applied to the predicted daily average residential wood smoke $PM_{2.5}$ contributions. The findings presented in the main body of this report are based on the emission scaling factors, called "Current Draft Inventory", shown in **Table C-1**. The results presented in this Appendix use the scaling factors, called "Consistent Inventory Methodology", shown in **Table C-2**.

Table C-1. Residential wood smoke emission inventory scaling factors called the "Current Draft Inventory".

County	Scale Factor
Sacramento	1.22
El Dorado	0.26
Placer	0.75
Yolo	0.85
Solano	0.75

Table C-2. Residential wood smoke emission inventory scaling factors called the "Consistent Inventory Methodology".

County	Scale Factor
Sacramento	1.22
El Dorado	0.26
Placer	0.85
Yolo	2.71
Solano	2.54

DEL PASO MANOR

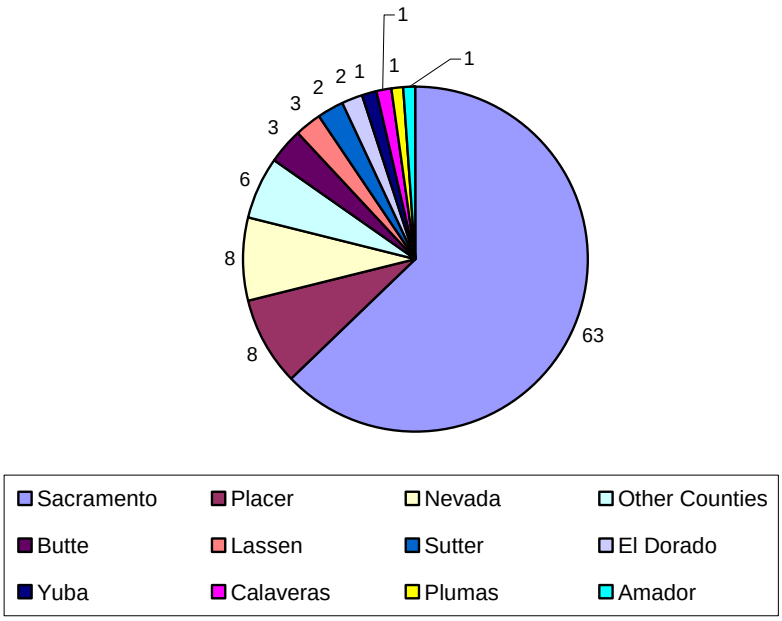

Figure C-1. TEAK estimated average percent contribution from each county to Del Paso Manor wood smoke primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 for the Del Paso Manor receptor during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

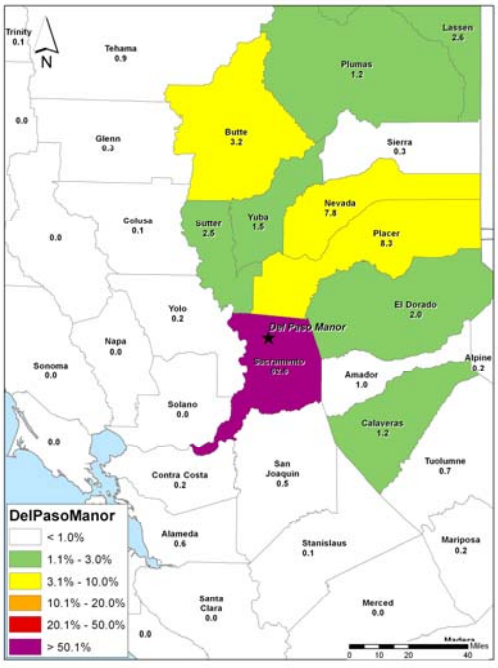

Figure C-2. Spatial plot of the TEAK estimated average percent contribution from each county to Del Paso Manor wood smoke primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 for the Del Paso Manor receptor during the winters of 2007/2008 and 2008/2009.

DAVIS

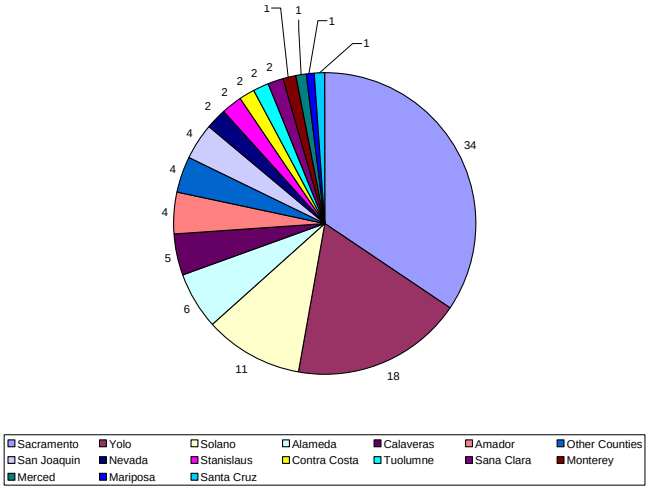

Figure C-3. TEAK estimated average percent contribution from each county to Davis primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 for the Davis receptor during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

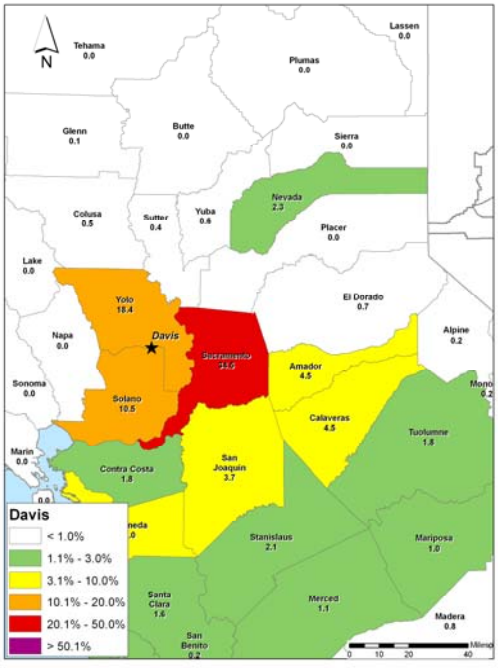

Figure C-4. Spatial plot of the TEAK estimated average percent contribution from each county to Davis primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 for the Davis receptor during the winters of 2007/2008 and 2008/2009.

FOLSOM

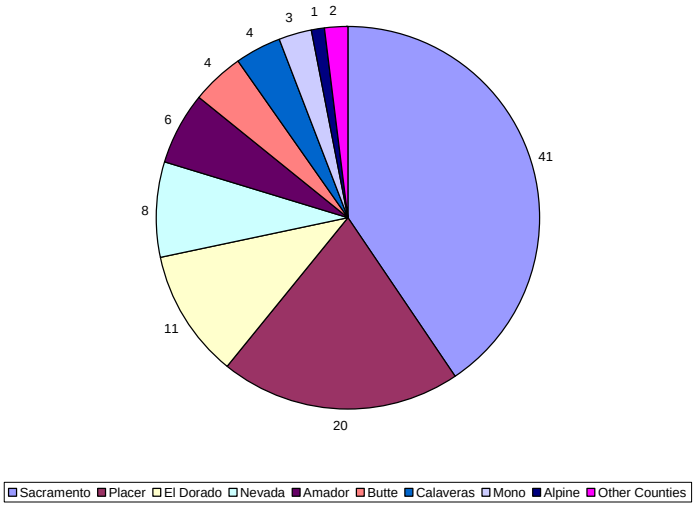

Figure C-5. TEAK estimated average percent contribution from each county to Folsom primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 for the Folsom receptor during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

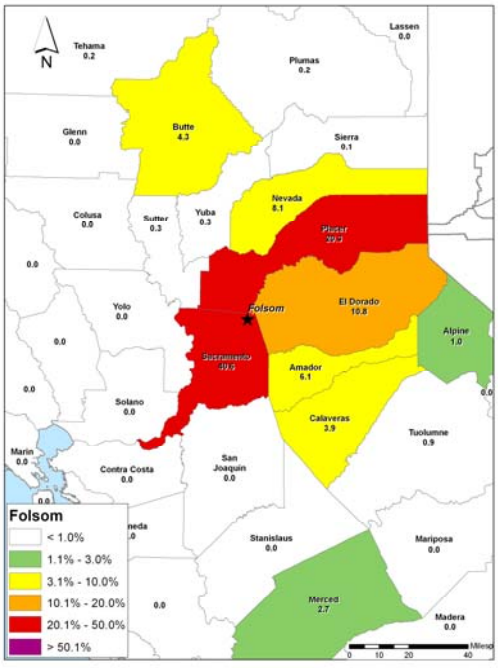

Figure C-6. Spatial plot of the TEAK estimated average percent contribution from each county to Folsom primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 for the Folsom receptor during the winters of 2007/2008 and 2008/2009.

BRUCEVILLE

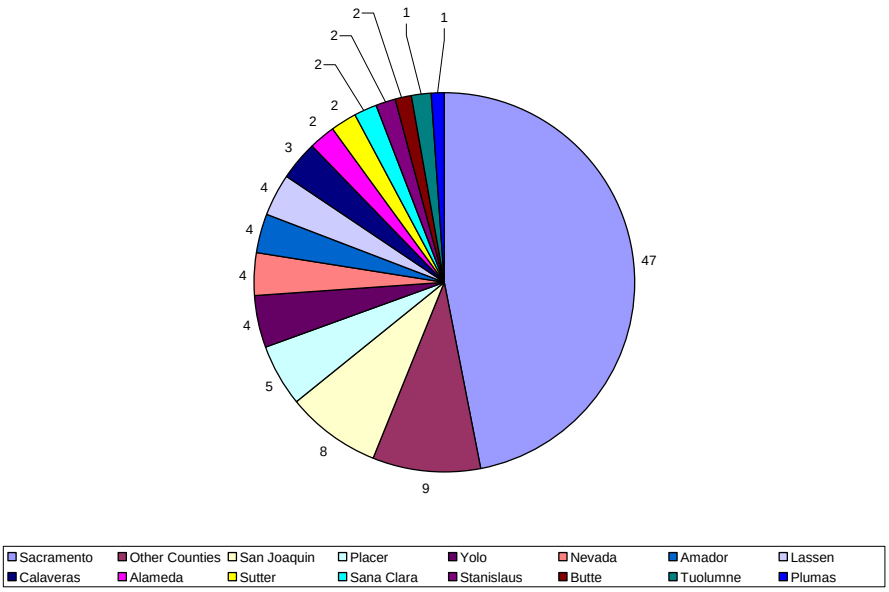

Figure C-7. TEAK estimated average percent contribution from each county to Bruceville primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 for the Bruceville receptor during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

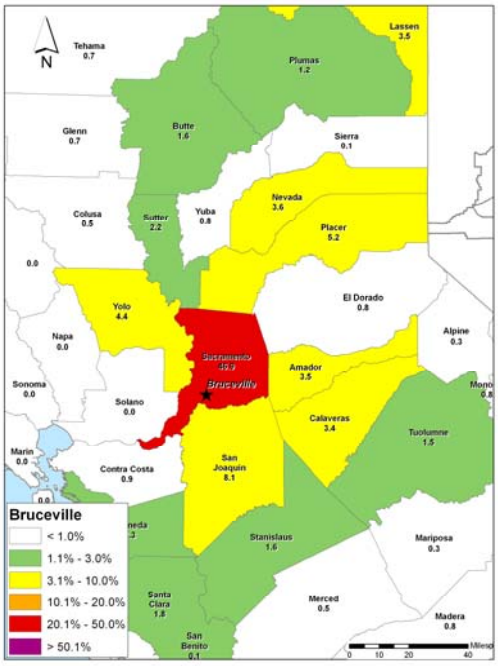

Figure C-8. Spatial plot of the TEAK estimated average percent contribution from each county to Bruceville primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 for the Bruceville receptor during the winters of 2007/2008 and 2008/2009.

ROSEVILLE

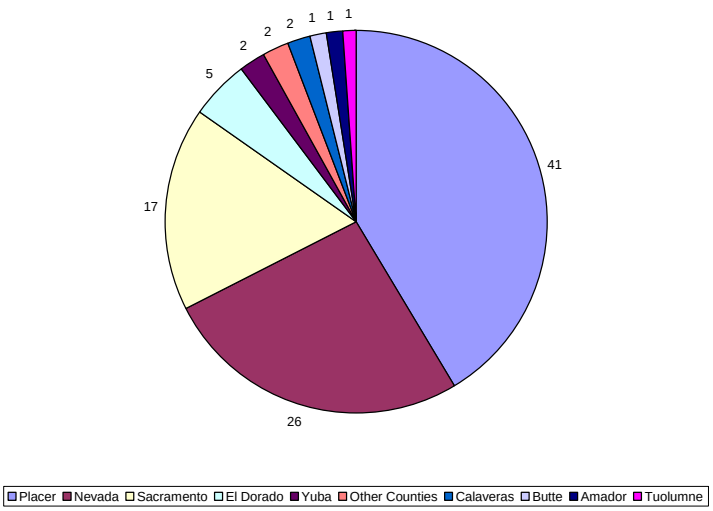

Figure C-9. TEAK estimated average percent contribution from each county to Roseville primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 for the Roseville receptor during the winters of 2007/2008 and 2008/2009. Only counties with contributions greater than 1% are shown individually.

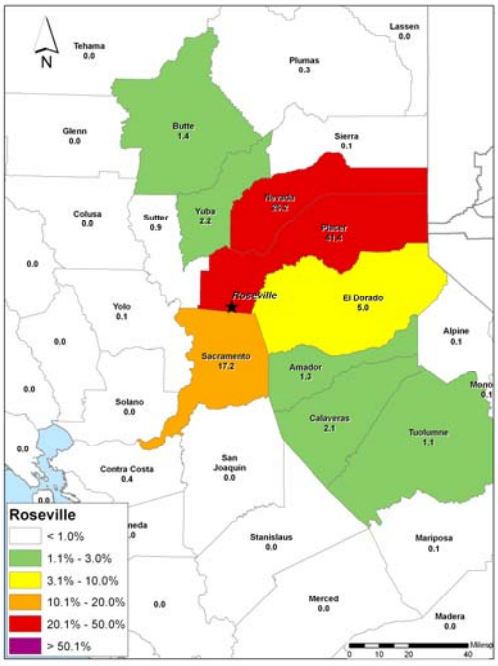

Figure C-10. Spatial plot of the TEAK estimated average percent contribution from each county to Roseville primary $PM_{2.5}$ on days when peak 24-hr $PM_{2.5}$ concentrations were greater than 35.5 µg/m^3 for the Roseville receptor during the winters of 2007/2008 and 2008/2009.

APPENDIX D

TEAK CONTRIBUTION RESULTS CONTRIBUTION RESULTS USING THE CONSISTENT INVENTORY METHODOLOGY FOR THE CRPAQS MODELING PERIOD

This appendix contains the TEAK contribution results in the form of data plots for the Del Paso Manor, Folsom, Bruceville, Davis, and Roseville receptors for December 15, 2000–January 9, 2001, using the "Consistent Inventory Methodology" for the emissions. The results are organized by site. Contributions from individual counties of less than 1% each are summed together and called "Other Counties". Distant counties (i.e., counties that are outside the 20 counties/sub-counties shown in Table 3-1) were also summed and called "Distant Counties".

The TEAK modeling method relied on estimates of residential wood smoke emissions. After the modeling simulations were completed, two sets of updated residential wood smoke emissions data for selected counties were provided by the SMAQMD in the form of county-level scaling factor adjustments to the original inventory used in the modeling. These updated emissions were used to reflect likely changes to the emission inventory by the California Air Resources Board. Because the modeling in this analysis deals only with inert, primary $PM_{2.5}$ emissions, it can be assumed that the absolute wood smoke contribution from a source region is linearly proportional to the emission rate in that source region. Therefore, these scaling factor adjustments were applied to the predicted daily average residential wood smoke $PM_{2.5}$ contributions. The findings presented in the main body of this report are based on the emission scaling factors, called "Current Draft Inventory", shown in **Table D-1**. The results presented in this Appendix use the scaling factors, called "Consistent Inventory Methodology", shown in **Table D-2**.

Table D-1. Residential wood smoke emission inventory scaling factors called the "Current Draft Inventory".

County	Scale Factor
Sacramento	1.22
El Dorado	0.26
Placer	0.75
Yolo	0.85
Solano	0.75

Table D-2. Residential wood smoke emission inventory scaling factors called the "Consistent Inventory Methodology".

County	Scale Factor
Sacramento	1.22
El Dorado	0.26
Placer	0.85
Yolo	2.71
Solano	2.54

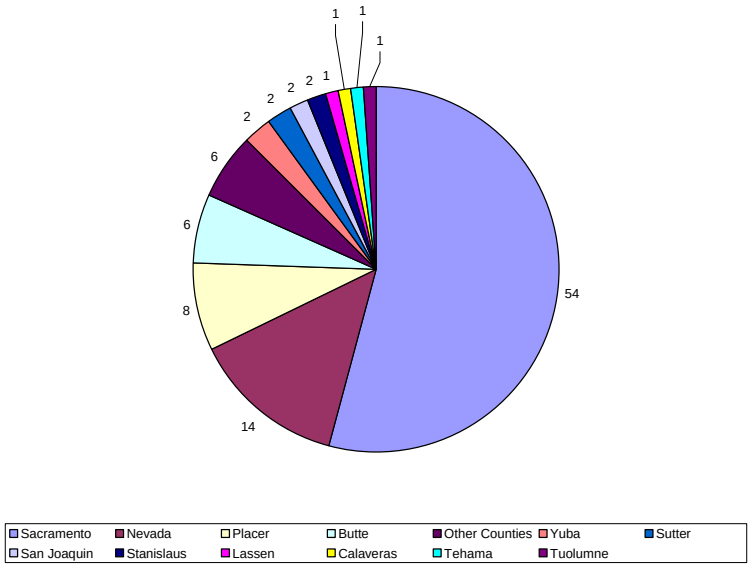

Figure D-1. TEAK estimated average percent contribution from each county to Del Paso Manor primary $PM_{2.5}$ during December 15, 2000–January 9, 2001. Only counties with contributions greater than 1% are shown individually.

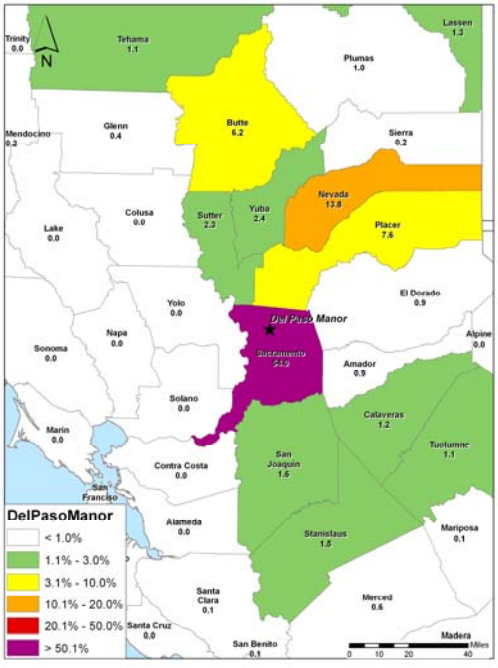

Figure D-2. Spatial plot of the TEAK estimated average percent contribution from each county to Del Paso Manor primary $PM_{2.5}$ during December 15, 2000–January 9, 2001.

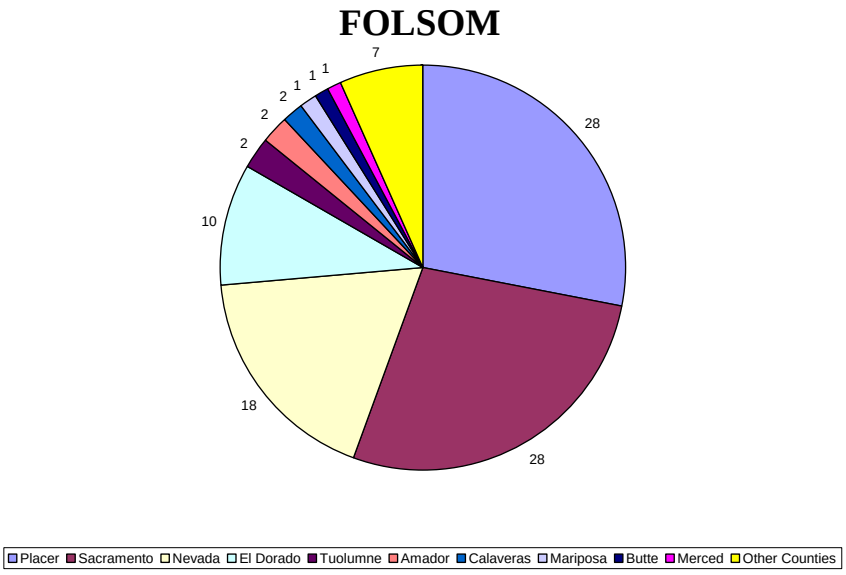

Figure D-3. TEAK estimated average percent contribution from each county to Folsom primary $PM_{2.5}$ during December 15, 2000–January 9, 2001. Only counties with contributions greater than 1% are shown individually.

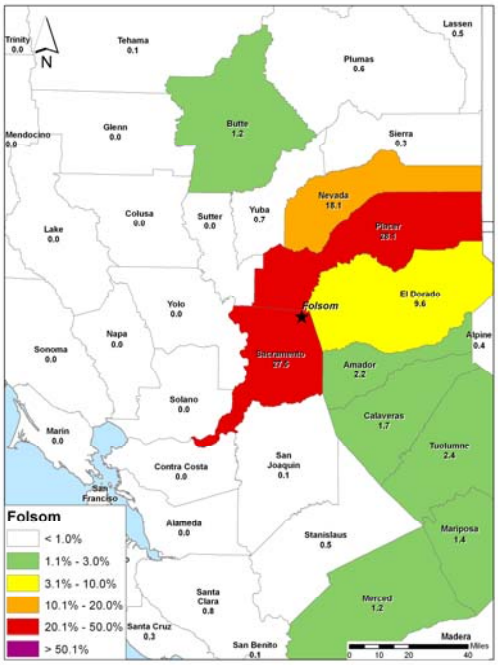

Figure D-4. Spatial plot of the TEAK estimated average percent contribution from each county to Folsom primary $PM_{2.5}$ during December 15, 2000–January 9, 2001.

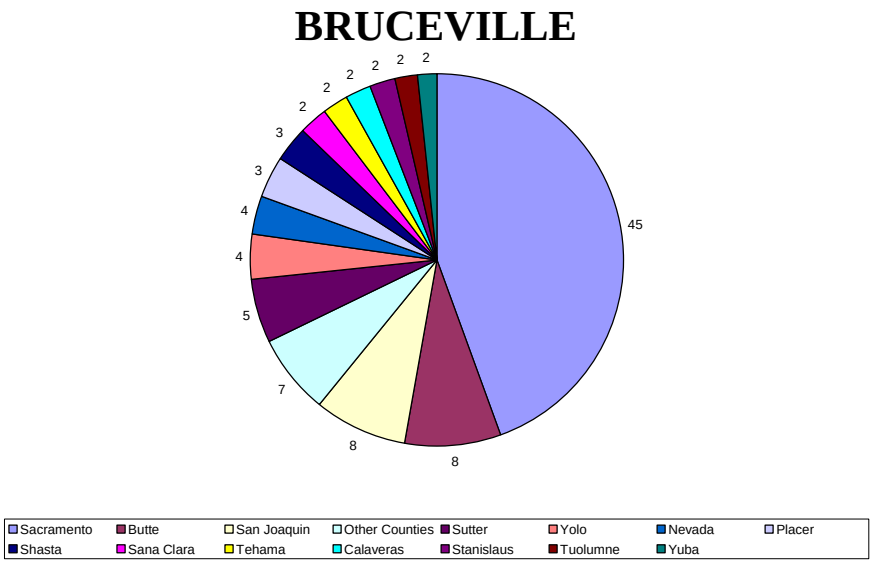

Figure D-5. TEAK estimated average percent contribution from each county to Bruceville primary $PM_{2.5}$ during December 15, 2000–January 9, 2001. Only counties with contributions greater than 1% are shown individually.

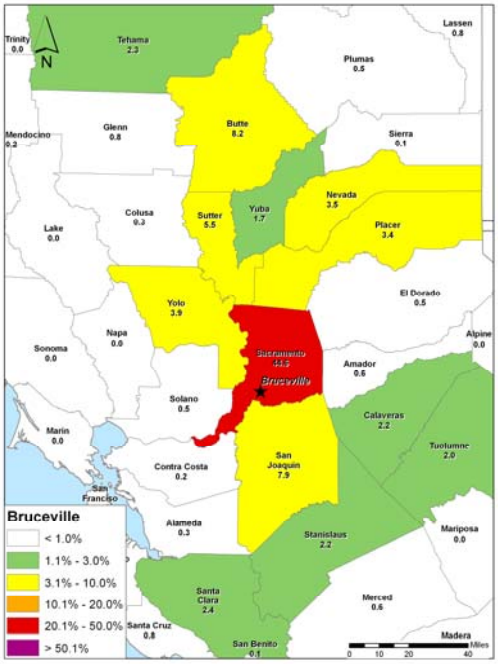

Figure D-6. Spatial plot of the TEAK estimated average percent contribution from each county to Bruceville primary $PM_{2.5}$ during December 15, 2000–January 9, 2001.

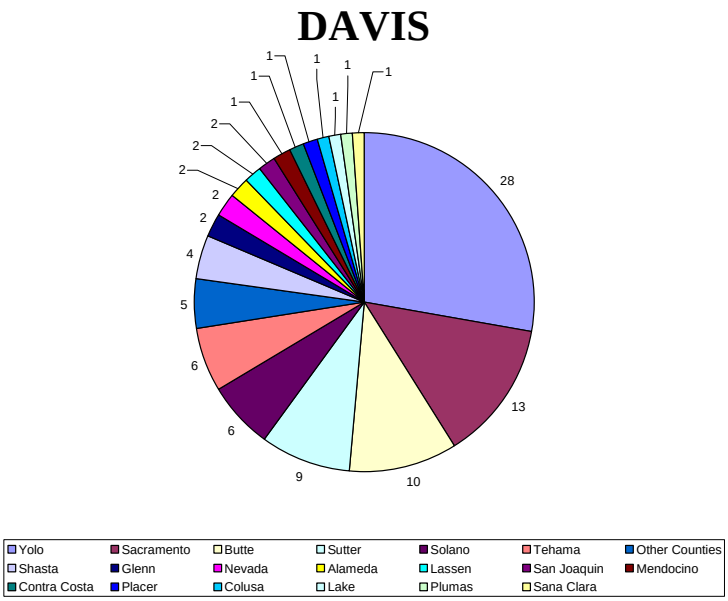

Figure D-7. TEAK estimated average percent contribution from each county to Davis primary $PM_{2.5}$ during December 15, 2000–January 9, 2001. Only counties with contributions greater than 1% are shown individually.

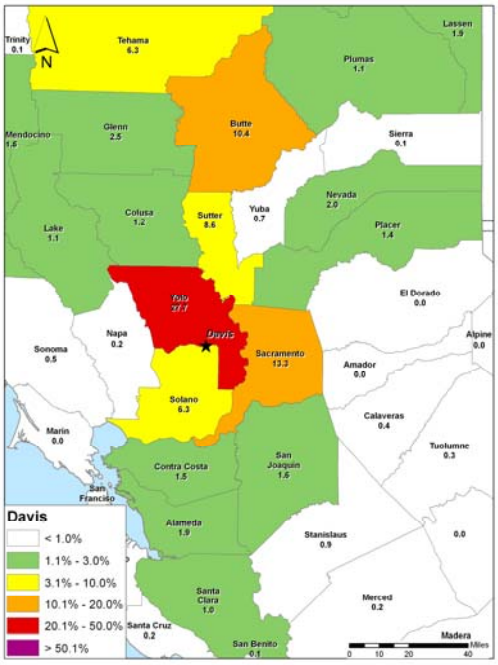

Figure D-8. Spatial plot of the TEAK estimated average percent contribution from each county to Davis primary $PM_{2.5}$ during December 15, 2000–January 9, 2001.

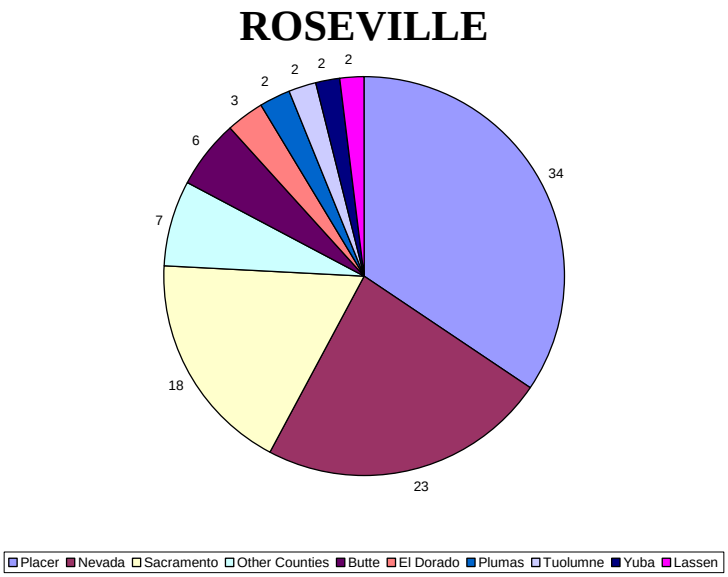

Figure D-9. TEAK estimated average percent contribution from each county to Roseville primary $PM_{2.5}$ during December 15, 2000–January 9, 2001. Only counties with contributions greater than 1% are shown individually.

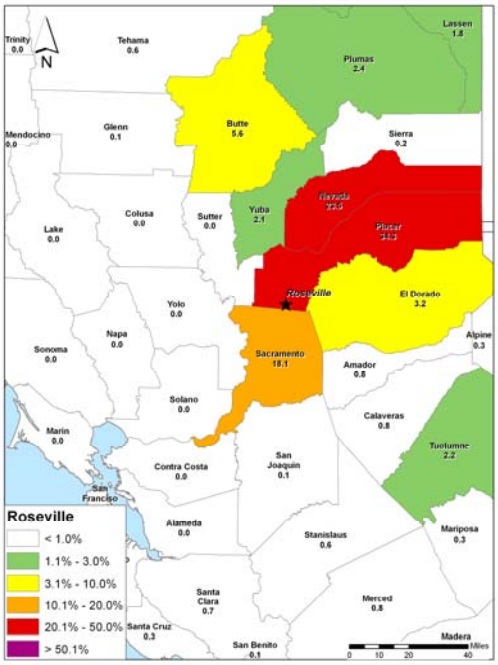

Figure D-10. Spatial plot of the TEAK estimated average percent contribution from each county to Roseville primary $PM_{2.5}$ during December 15, 2000–January 9, 2001.

APPENDIX E

TWENTY-FOUR-HOUR AVERAGE $PM_{2.5}$ CONCENTRATIONS ON MODELING ANALYSIS DATES

This appendix contains 24-hr average $PM_{2.5}$ concentrations from the Bruceville, Davis, Del Paso Manor, Folsom, and Roseville receptors for the dates used in the MM5/CAMx and TEAK modeling analyses. The 2007–2009 data were obtained from the EPA Air Quality System. The 2000–2001 data were obtained from the Sacramento Metropolitan Air Quality Management District. The only receptor with $PM_{2.5}$ data for December 15, 2000, through January 9, 2001, is Del Paso Manor.

Table E-1. Observed 24-hr average $PM_{2.5}$ concentrations for Bruceville, Davis, Del Paso Manor, Folsom, and Roseville receptors for the dates used in the MM5/CAMx and TEAK modeling analysis.

Date	Bruceville	Davis	Del Paso Manor	Folsom	Roseville
12/15/2000			12.7		
12/16/2000			34.3		
12/17/2000			16.4		
12/18/2000			48.7		
12/19/2000			50.9		
12/20/2000			Missing		
12/21/2000			Not Valid		
12/22/2000			29.6		
12/23/2000			52.1		
12/24/2000			17.4		
12/25/2000			62.1		
12/26/2000			69.7		
12/27/2000			55.7		
12/28/2000			69.5		
12/29/2000			84.7		
12/30/2000			91.7		
12/31/2000			123.1		
1/1/2001			128.2		
1/2/2001			88.0		
1/3/2001			63.9		
1/4/2001			57.5		
1/5/2001			48.8		
1/6/2001			80.2		
1/7/2001			118.7		
1/8/2001			44.0		
1/9/2001			23.7		
11/25/2007	33.8	20.8	45.0	31.3	37.6
11/26/2007	33.5	17.7	52.3	25.7	25.2
11/29/2007	31.5	9.2	38.7	21.4	17.4
12/14/2007	40.8	34.3	47.7	35.9	33.4
12/15/2007	37.3	38.5	41.1	37.7	39.5
12/16/2007	30.9	30.6	43.2	23.8	26.5
12/17/2007	38.3	36.6	32.8	20.9	27.3
1/1/2008	19.3	10.9	41.5	11.4	20.9
1/2/2008	25.0	17.6	35.7	14.7	18.0
1/18/2008	30.4		51.0	28.8	34.2
1/19/2008	37.7		49.9	26.0	31.2
2/10/2008	28.2	16.9	37.3	12.3	20.5
2/17/2008	25.8	21.0	35.7	15.1	17.8
11/22/2008	28.2	22.7	49.4	32.1	32.9
11/23/2008	37.3	19.8	60.7	44.9	44.2

Table E-1. Observed 24-hr average $PM_{2.5}$ concentrations for Bruceville, Davis, Del Paso Manor, Folsom, and Roseville receptors for the dates used in the MM5/CAMx and TEAK modeling analysis.

Date	Bruceville	Davis	Del Paso Manor	Folsom	Roseville
11/24/2008	26.1	12.8	41.6	41.0	38.3
11/25/2008	36.3	25.8	35.8	27.6	28.8
11/26/2008	29.3	18.7	41.5	33.8	41.0
11/29/2008	21.9	15.6	35.6	19.6	21.0
11/30/2008	20.0	23.4	42.6	20.9	20.4
12/5/2008	31.1	17.3	40.2	32.6	31.7
12/10/2008	26.9	16.3	40.2	13.8	20.5
12/11/2008	45.0	39.8	48.3	29.9	32.5
12/12/2008	39.4	26.8	53.7	44.5	59.5
1/10/2009	23.4	18.8	43.5	16.5	17.1
1/11/2009	29.6	21.3	55.3	26.0	26.3
1/12/2009	37.3	32.0	37.1	30.0	22.6
1/13/2009	32.9	31.9	40.1	19.0	20.1
1/14/2009	33.1	20.0	50.3	18.0	18.9
1/15/2009	32.2	18.2	43.0	14.7	13.8
1/16/2009	36.4	30.0	48.5	18.1	22.5
1/17/2009	28.9	27.2	39.1	7.7	10.6
1/30/2009	28.0	25.7	39.7	19.8	23.5