CHAPTER 9

ATTRIBUTION OF AEROSOL SPECIES TO SOURCES USING CHEMICAL MASS BALANCE AND REGRESSION ANALYSIS

9.1 INTRODUCTION

The primary strategy taken in this chapter for purposes of estimating various source contributions to measured aerosol levels will be to use Chemical Mass Balance (CMB) modeling in combination with Tracer Mass Balance Regression (TMBR). CMB will be used to establish relative amounts of each tracer species associated with various sources and these fractional levels can then be use in a TMBR model to establish estimates of each source or source types' contribution to the aerosol species of interest. This approach will be referred to as CMB regression. Furthermore, results of the CMB analysis can be used to investigate how much each of the trace elements that showed a statistical link with visibility reducing aerosols is associated with various sources.

9.2 THE CHEMICAL MASS BALANCE ANALYSIS

As discussed in Appendix 1, chemical mass balance consists of a least-squares solution of a set of linear equations, which expresses each receptor concentration of a chemical species as a linear sum of products of source profile species and source contributions. The source profile species (the fractional amount of the species in the emissions from each source type) and the receptor concentrations serve as input data to the CMB model. The output consists of the amount contributed by each source type to each chemical species concentration.

PREVENT data used in the CMB analysis consisted of 12-hour averages in the PM 2.5μm particle fraction at Tahoma Woods and Paradise. Analysis was not carried out on Marblemount data because a high sensitivity trace element analysis was not carried out at that site.

The source profiles used in the analysis are included in Appendix 5. The sources examined as to their potential contribution to primary particles at Tahoma Woods and Paradise are:

Coal-fired power plant	Kraft recovery furnace	Cement kiln
Lime kiln	Sulfite recovery boiler	Aluminum proc
Copper smelter	Residual oil combustion	Transportation
Oil-fired power plant	Marine aerosol	Wood-fired boiler
Agricultural burning	Broadcast burning	Municipal incinerator
12-soil dust profiles		

The 12 soil dust profiles are quite similar, as are a number of other profiles such as burning and recovery boiler profiles.

9.2.1 CMB Source Contributions to Trace Elements

The results of the regression analysis are presented along with the measured and predicted concentrations of the various trace element species. Additionally, the concentration of trace element species associated with each source type is also presented. Species used in the analysis are b_{abs}, Br, Cu, Fe, K, Mn, Na, Pb, V, Zn, Si, Al, Ca, Ti, Zr, Ni, As, and Se. Other elements were not used because they were below the detectable limit much of the time.

In most cases, five or less sources were adequate to develop a reasonable model as judged by the r^2 value. The addition of more sources resulted in increased standard errors or negative regression coefficients suggesting multicolinearity between variables. A variety of soil profiles were used with varying degrees of model fit. The Richland and Dog Mountain profiles in conjunction with the coal-fired power plant profile gave the best overall fit on elements such as Si, Al, Ca, and Fe. The lime kiln and kraft recovery profiles were almost interchangeable, while in many cases the interchange of some "burn profiles" didn't change the model fit significantly.

Since the analysis is being used more to derive a semi-quantitative understanding for the relative importance of various source types, the CMB analysis was carried out with five generic sources: soil dust (Richland, Washington); coal-fired power plant; kraft recovery or lime profile; transportation; and burning (agricultural burning). A program was written to include all five sources in the analysis on the first "pass" and then remove, in a sequential manner, sources with negative coefficients. Appendices 6 and 7 contain the generic output from the CMB analysis for Tahoma Woods and Paradise sites, respectively. It is emphasized that on any given day the CMB model may be improved slightly by using different sources within each source group. However, the general trends do not change.

9.2.2 Tahoma Woods

The first plot in Figures 9-1 through 9-4 are temporal plots of ammonium sulfate ($\mu g/m^3$), ammonium nitrate ($\mu g/m^3$), organics ($\mu g/m^3$), and light-absorbing carbon ($\mu g/m^3$), respectively. The remaining temporal plots in each figure correspond to the relative contribution of coal-fired power plants, burning, kraft or lime facilities, and transportation. The variable plotted is the Se for coal-fired power plants, K for burning, Na for kraft or lime, and Pb for transportation. Units are in ng/m^3. These trace elements are plotted to show relative contributions of each source type. Other trace elements could be used or the sum of the masses of all elements for a source could be used. However, the relative temporal trends would be the same since the relative ratios of one trace element to another remain constant for any given source.

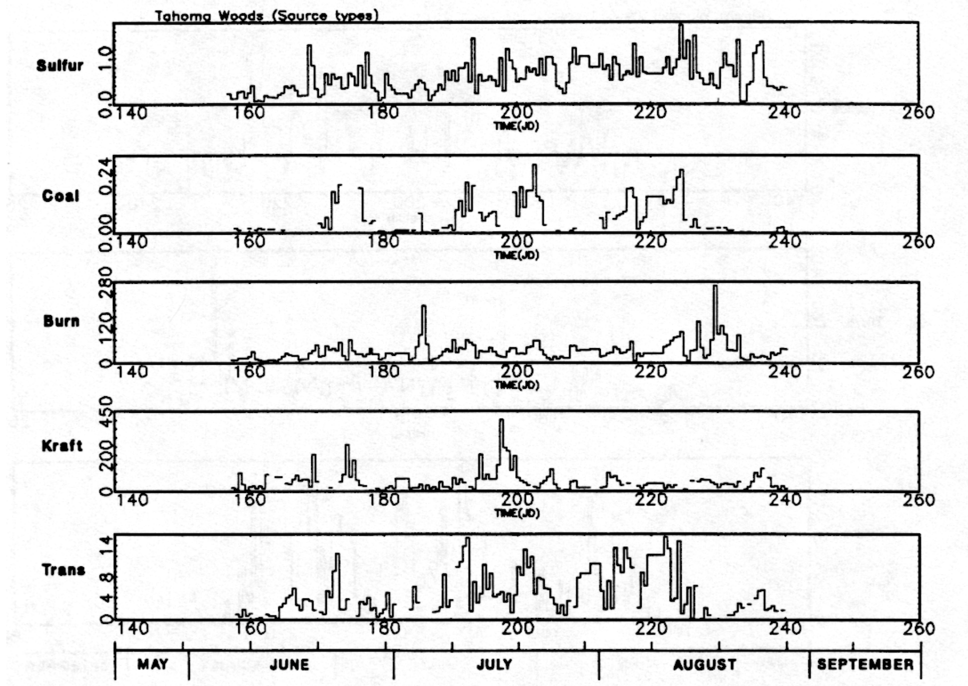

Figure 9-1. Temporal plot of the elemental sulfur and the relative source strength of coal-fired power plants, burning, pulp and paper mills, and transportation at Tahoma Woods. Units of sulfur are μg/m^3.

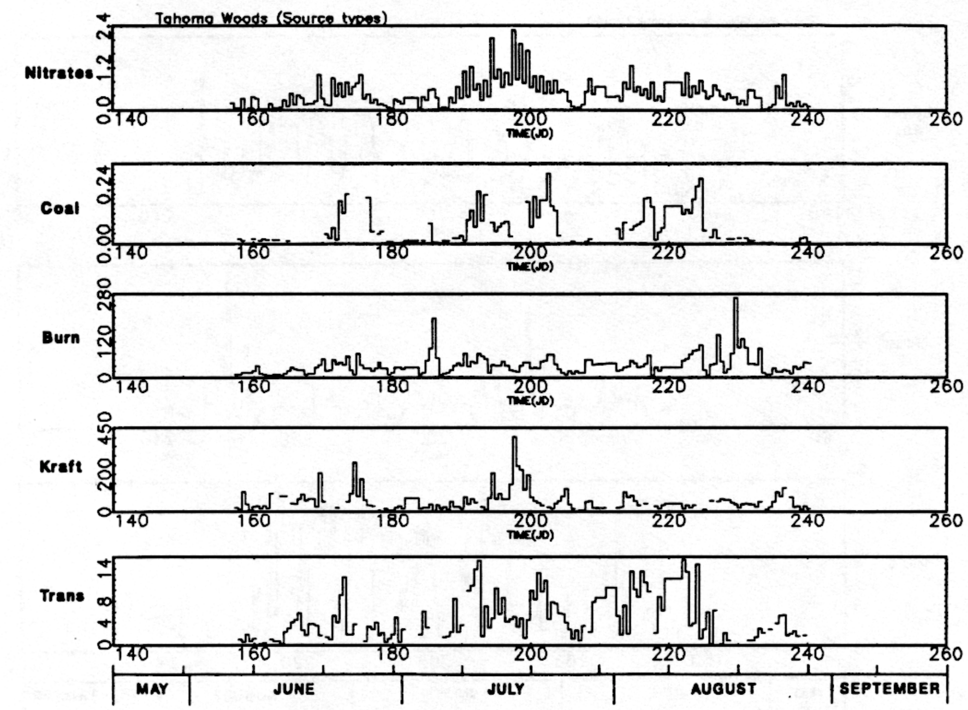

Figure 9-2. Temporal plot of ammonium nitrate and the relative source strength of coal-fired power plants, burning, pulp and paper mills, and transportation at Tahoma Woods. Units of nitrates are μg/m^3.

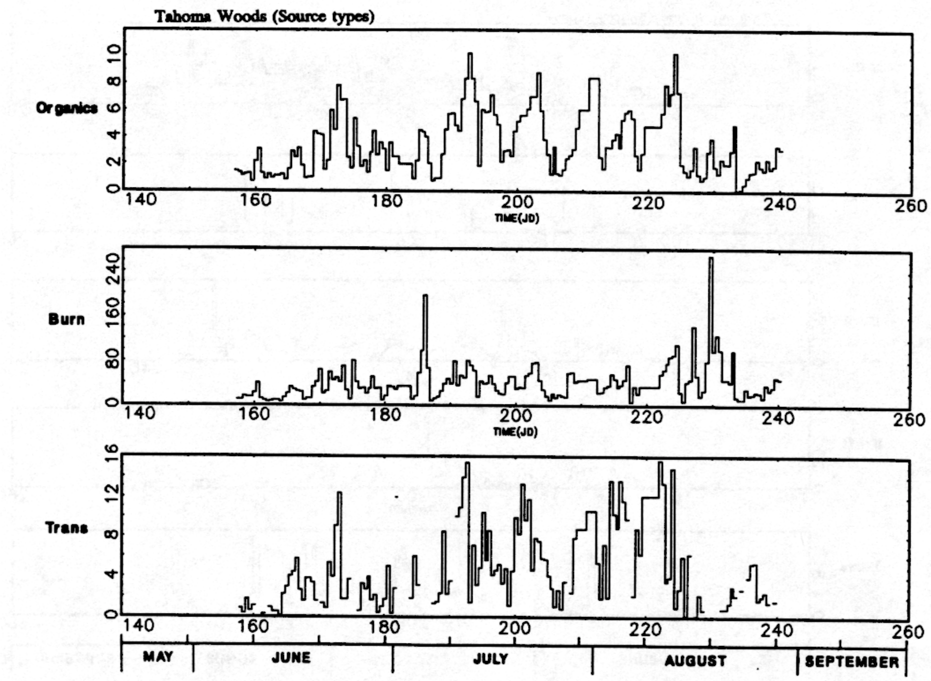

Figure 9-3. Temporal plot of organics and the relative source strength of burning, and transportation at Tahoma Woods. Units of organics are μg/m^3.

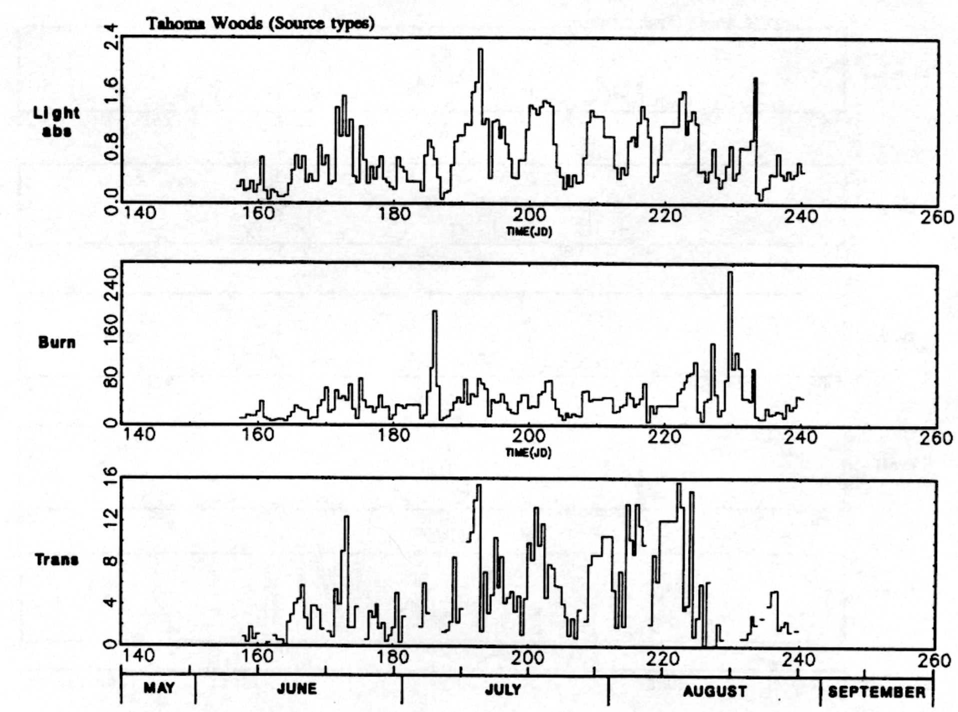

Figure 9-4. Temporal plot of light-absorbing carbon and the relative source strength of burning, and transportation at Tahoma Woods. Units of light-absorbing carbon are μg/m^3.

Tables 9-1 and 9-2 present the fractional contribution of each source type to the trace elements used in the exploratory regression analysis, presented in the previous chapter. Table 9-1 is with the kraft source profile while Table 9-2 uses the lime kiln source. There is very little difference between the two analyses. The element Si is split about 60-40% between soil and coal, while coal contributed 80-90% of the Se and greater than 90% of the arsenic. Over 80% of the K and 90% of the Cu is associated with burning. Burning is also responsible for 15-20% of the observed bromine. Transportation is responsible for the bulk of the Br at 70-80% and Pb at greater than 90%. Either the kraft or lime profile accounts for most of the measured Na. At inland sites, such as Tahoma Woods, Na may be a good tracer for pulp and paper mill activity.

Comparing Table 9-1 or 9-2 to Table 8-13 in Chapter 8 gives some additional insight to the source of the various visibility reducing aerosols. Referring to Table 8-13, about 30% of the sulfur is associated with Br and much of the Br is linked to transportation. Apparently, a significant fraction of ambient sulfur is associated with transportation activity. Se is also associated with sulfur, and most Se is identified with the coal-fired power plant profile. Si is also related to ambient sulfur concentrations and Si is split between soil and the coal-fired power plant profile. Possibly some sulfur is associated with soil dust.

About 20% of the nitrates are linked to Na and most of the Na is associated either with the kraft or lime kiln profile. Se and therefore, coal-fired power plants are associated with nitrates. However, Si is also linked to nitrates, and it is hard to imagine soil and nitrates being associated with each other. Possibly it is the coal-fired power plant Si that is associated with nitrates or a soil and fertilizer mix that is being measured.

The implication of the analysis as to the source of organic aerosols is interesting. Nearly 70% of the organics are associated with Br and Pb, and 80-90% of these two elements are linked to urban (transportation) emissions. In the empirical regression analysis K didn't show up as a significant independent variable, and as such, burning is not linked to organics. Furthermore, most of the light-absorbing carbon (approximately 60%) is associated with urban activity.

These relationships can be further explored using regressional techniques with the aerosols of interest as the dependent variables and the relative source emissions as independent variables. These results are summarized in Tables 9-3 through 9-6. Table 9-3 shows the results for sulfur. The relationship between sulfur and the various source types is weak. Coal-fired power plants and burning activity both show up with highly significant coefficients, but together they account for only about 40% of the sulfur.

The nitrate model is highly significant with an r^2 of 0.79. The analysis suggests that over 60% of the nitrates are associated with either lime kiln or pulp and paper mill activity. Coal-fired power plants are associated with over 30% of the nitrate, while transportation and burning activity each contribute about 10% to the ambient nitrate.

The organic and light-absorbing carbon model are also highly significant with an r^2 of 0.77 and 0.83, respectively. The model implies that transportation activity is responsible for 54% of measured organics, while burning contributes about 35%. On the other hand, 70% of the light-absorbing carbon is linked to burning and 30% to transportation.

Table 9-1. Fraction that each source type contributes to the various trace elements listed. Elements were measured at Tahoma Woods and kraft profile was used (see Appendix 6).

	Soil	Coal	Burn	Kraft	Trans
Si	0.5880	0.3705	0.03542	0.005340	0.0007148
Pb	0.000	0.01005	0.04889	0.007010	0.9340
Se	0.000	0.8671	0.01951	0.1134	0.000
Br	0.000	0.000	0.1615	0.08140	0.7571
Na	0.000	0.000	0.03387	0.9661	0.000
K	0.04898	0.03200	0.8416	0.07737	6.269E-05
Cu	0.000	0.04598	0.9487	0.002327	0.003032
As	0.000	0.9254	0.02083	0.05377	0.000
b_{abs}	0.000	0.000	0.6474	0.001266	0.3514

Table 9-2. Fraction that each source type contributes to the various trace elements listed. Elements were measured at Tahoma Woods and lime profile was used (see Appendix 6).

	Soil	Coal	Burn	Lime	Trans
Si	0.5829	0.3800	0.03587	0.0006467	0.0006510
Pb	0.000	0.01126	0.05399	0.006010	0.9287
Se	0.000	0.8999	0.02007	0.08007	0.000
Br	0.000	0.000	0.1862	0.02776	0.7861
Na	0.000	0.000	0.03434	0.9657	0.000
K	0.05018	0.03391	0.8798	0.03607	5.901E-05
Cu	0.000	0.04634	0.9430	0.007980	0.002713
As	0.000	0.9417	0.02101	0.03724	0.000
b_{abs}	0.000	0.000	0.6651	0.009917	0.3250

Table 9-3. Tahoma Woods: The first part of this table are the results of an OLS regression using sulfur as the dependent variable and the relative source strengths of coal-fired power plants, and burning as independent variables. The second half of the table, part b, presents the estimated sulfur mass associated with coal-fired power plants and burning, respectively, along with the fraction of sulfur attributed to each source type. Units of elemental sulfur are ng/m^3.

a. Dependent variable = Sulfur, r^2 = 0.345

Variable	Estimate	Std Error	t-value	Prob t	Std Est	Cor with Dep Var
Constant	316.03	53.00	5.96	0.00	--	--
Coal fired	2230.49	426.21	5.23	0.00	0.47	0.54
Burn	2.63	0.98	2.69	0.009	0.24	0.39

b.

Variable	Mean	Std Dev	Variance	Minimum	Maximum	Fraction
Coal fired	94.39	143.34	20545.72	0.00	632.00	0.18
Burn	106.01	89.75	8054.52	0.00	704.23	0.20

Table 9-4. Tahoma Woods: The first part of this table are the results of an OLS regression using ammonium nitrate as the dependent variable and the relative source strengths of burning, transportation, coal-fired power plants, and pulp and paper mills as independent variables. The second half of the table, part b, presents the estimated nitrate mass associated with each source type along with the fraction of nitrates attributed to each source type. Units of elemental nitrates are μg/m^3.

a. Dependent variable = Nitrate, r^2 = 0.786

Variable	Estimate	Std Error	t-value	Prob t	Std Est	Cor with Dep Var
Constant	-0.10	0.06	-1.64	0.11	--	--
Burn	0.004	0.002	2.64	0.01	0.20	0.46
Trans	0.02	0.01	2.37	0.02	0.16	0.43
Coal	1.34	0.50	2.69	0.01	0.22	0.53
Pulp	0.01	0.00	11.02	0.00	0.68	0.75

b.

Variable	Mean	Std Dev	Variance	Minimum	Maximum	Fraction
Burn	0.17	0.14	0.02	0.00	1.13	0.28
Trans	0.06	0.06	0.004	0.00	0.24	0.10
Coal fired	0.06	0.09	0.01	0.00	0.38	0.09
Pulp	0.32	0.39	0.15	0.00	2.73	0.52

Table 9-5. Tahoma Woods: The first part of this table are the results of an OLS regression using organics as the dependent variable and the relative source strengths of burning, and transportation as independent variables. The second half of the table, part b, presents the estimated organic mass associated with each source type along with the fraction of organics attributed to each source type. Units of elemental organics are μg/m^3.

a. Dependent variables = Organics, r^2 = 0.772

Variable	Estimate	Std Error	t-value	Prob t	Std Est	Cor with Dep Var
Constant	0.28	0.18	1.53	0.13	--	--
Burn	0.03	0.003	9.97	0.00	0.43	0.46
Trans	0.43	0.02	17.62	0.00	0.75	0.77

b.

Variable	Mean	Std Dev	Variance	Minimum	Maximum	Fraction
Burn	1.12	0.95	0.91	0.00	7.46	0.36
Trans	1.67	1.70	2.91	0.00	6.65	0.54

Table 9-6. Tahoma Woods: The first part of this table are the results of an OLS regression using light-absorbing carbon as the dependent variable and the relative source strengths of burning, and transportation as independent variables. The second half of the table, part b, presents the estimated light absorbing carbon mass associated with each source type along with the fraction of light-absorbing carbon attributed to each source type. Units of elemental light-absorbing carbon are μg/m^3.

a. Dependent variable = Carbon, r^2 = 0.826

Variable	Estimate	Std Error	t-value	Prob t	Std Est	Cor with Dep Var
Constant	-0.02	0.04	-0.47	0.64	--	--
Burn	0.01	0.00	14.64	0.00	0.59	0.79
Trans	0.06	0.005	12.23	0.00	0.50	0.73

b.

Variable	Mean	Std Dev	Variance	Minimum	Maximum	Fraction
Burn	0.52	0.44	0.20	0.00	3.47	0.70
Trans	0.23	0.23	0.05	0.00	0.91	0.30

9.2.3 Paradise

A similar analysis was carried out on the Paradise data set. Tables 9-7 and 9-8 are summaries of the contribution of various source types to the trace elements used in the analysis, while Figures 9-5 through 9-8 are the temporal plots of the visibility reducing aerosol and sources contributing to that aerosol's ambient concentration.

Referring to Tables 9-7 and 9-8 it can be seen that the soil-related trace elements are about evenly divided between the soil and coal-fired power plant profiles, while 80-90% of the K and Cu are linked to burning activity. The kraft or lime profile are associated with over 90% of the Na, and transportation contributes to most of the measured Pb. Br is split between transportation and burning at 75% and 20% respectively. About 80% of the As and Se is linked to the coal-fired power plant profile.

Again it is helpful to compare Tables 9-7 and 9-8 to Table 8-13 in the previous chapter. The weakest link between any of the visibility reducing aerosols and trace elements is sulfur. The model r^2 is only 0.52. However, the coefficients are highly significant and insight into sulfur origin can be gained. About 30-40% of the sulfur is associated with Se, 50% with high temperature elemental carbon and 10% with Cu. Most of the measured Se is attributed to the coal-fired power plant signature and Cu is linked to burning activity. However, the origin of ECHT and its association with sulfur is less clear. One expects ECHT to be associated with diesel emissions or possibly burning activity. But if that is the case, then sulfur should be associated with Pb or Br, in case of diesels, or with K in the case of fire. As discussed in Chapter 7 it is quite possible that sulfur and ECHT are internally mixed and as such the correlation between sulfur and ECHT is higher than with other trace elements not chemically mixed with the aerosol. Because Cu is associated with burning and independent of ECHT (see Factor Analysis Results in Chapter 7), the likely source of ECHT is transportation activity.

Like Tahoma Woods, nitrates at Paradise are strongly associated with Na, and most Na originates either with pulp and paper mill activity or the lime profile. On the order of 10% of the nitrate is associated with coal-fired power plants and burning. About 20-30% of the nitrates are linked to ECHT and, as discussed previously, the most likely source of ECHT is transportation.

Organics are strongly linked (over 50%) to Br and Pb and these have been shown to be primarily from transportation-related activity. Only a small fraction of organics are associated with K and thus burning. The association of organics with Si is not clear. Neither soil or coal-fired power plants, the major contributors to Si, are significant emitters of organics. Light- absorbing carbon is primarily associated with Pb and thus transportation, and also with K whose origin lies in burning.

Again the relationship between visibility reducing aerosols and sources can be explored with regression analysis using aerosols and source strengths as dependent and independent variables, respectively. The relationships between aerosols and sources are not nearly as robust, as indicated by r^2 values, as they are at Tahoma Woods. The results of this type of analysis do not lead to any "strong" relationships between sources and sulfur. Figure 9-8, which is a

Table 9-7. Fraction that each source type contributes to the various trace elements listed. Elements were measured at Paradise and Kraft profile was used (see Appendix 5).

	Soil	Coal	Burn	Kraft	Trans
Si	0.48	0.41	0.11	0.002	0.00
Pb	0.00	0.02	0.06	0.01	0.92
Se	0.00	0.78	0.18	0.04	0.00
Br	0.00	0.00	0.18	0.07	0.75
Na	0.00	0.00	0.04	0.96	0.00
Is	0.06	0.06	0.83	0.06	5.4E-05
Cu	0.00	0.08	0.92	0.002	0.003
As	0.00	0.80	0.18	0.02	0.00
b_{abs}	0.00	0.00	0.68	0.001	0.32

Table 9-8. Fraction that each source type contributes to the various trace elements listed. Elements were measured at Paradise and lime profile was used (see Appendix 5).

	Soil	Coal	Burn	Lime	Trans
Si	0.50	0.39	0.11	0.00	0.00
Pb	0.00	0.02	0.06	0.005	0.91
Se	0.00	0.78	0.19	0.03	0.00
Br	0.00	0.00	0.20	0.02	0.78
Na	0.00	0.00	0.05	0.95	0.00
K	0.07	0.06	0.85	0.03	5.2E-05
Cu	0.00	0.08	0.92	0.01	0.002
As	0.00	0.79	0.20	0.01	0.00
b_{abs}	0.00	0.00	0.68	0.01	0.31

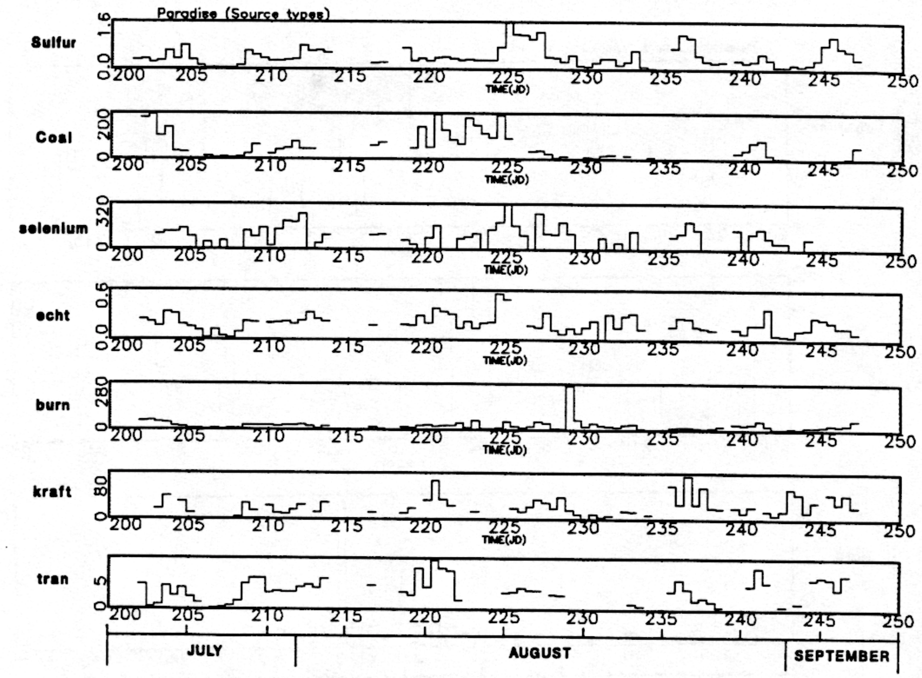

Figure 9-5. Temporal plot of the elemental sulfur, and the relative source strength of coal-fired power plants, measured Se concentration, measured ECHT, relative source strengths of burning, pulp and paper mills, and transportation at Paradise. Units of sulfur and ECHT are $\mu g/m^3$ while Se is units of ng/m^3.

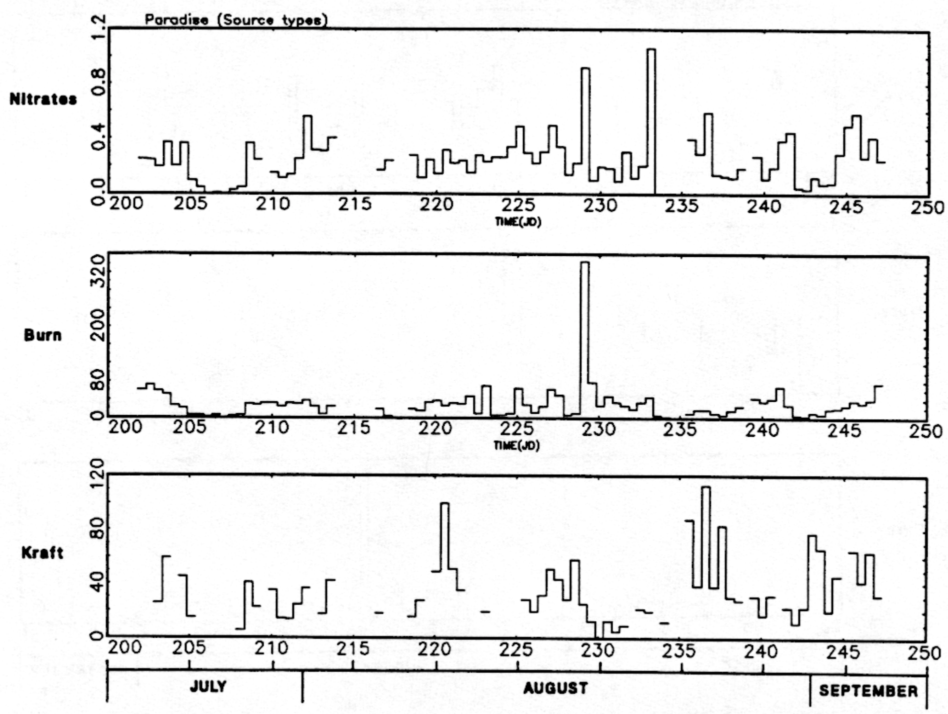

Figure 9-6. Temporal plot of ammonium nitrate, and the relative source strength of burning, and pulp and paper mills at Paradise. Units of nitrates are $\mu g/m^3$.

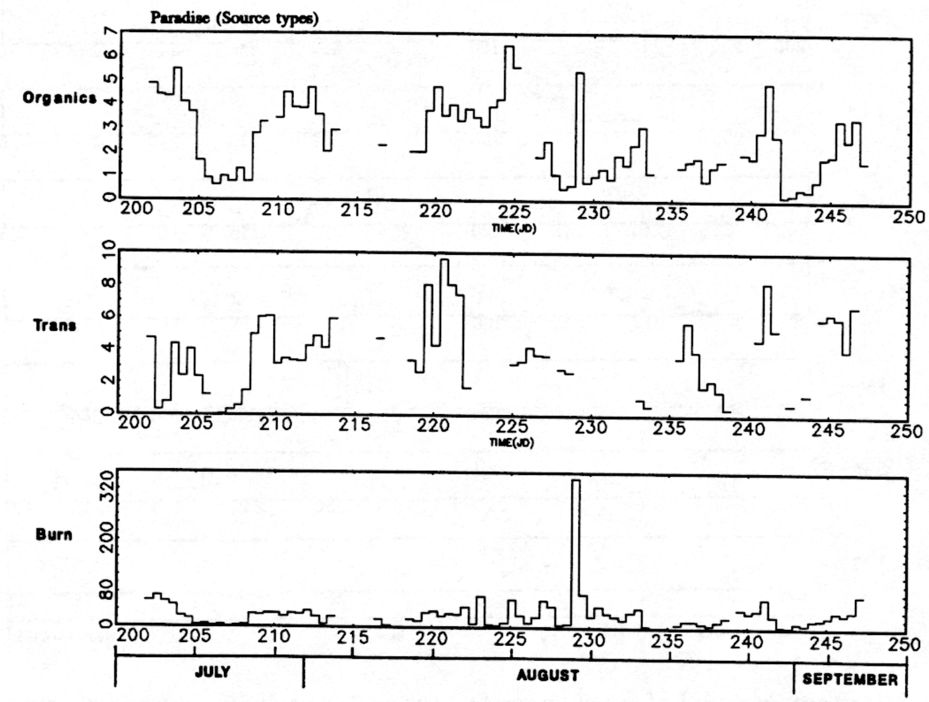

Figure 9-7. Temporal plot of organics and the relative source strength of burning, and transportation at Paradise. Units of organics are μg/m^3.

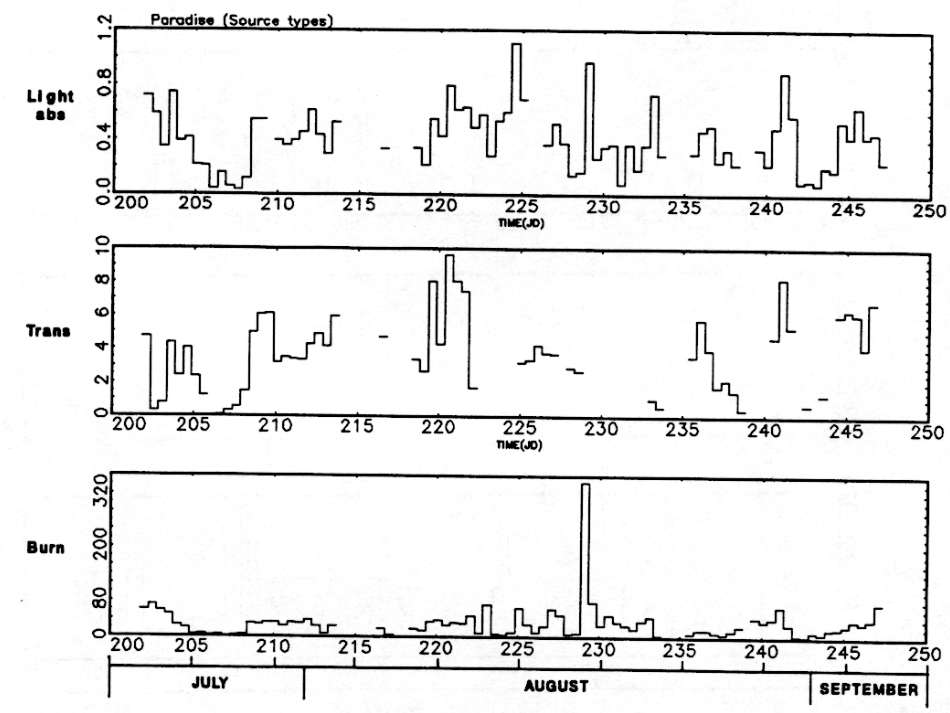

Figure 9-8. Temporal plot of light-absorbing carbon, and the relative source strength of burning, and transportation at Paradise. Units of light absorbing carbon are μg/m^3.

temporal plot of sulfur, coal-fired power plant Se, measured Se, ECHT, burn K, kraft Na, and transportation Pb, shows why significant statistical relationships do not exist. First, there is little correlation between coal Se and measured Se. Possibly the coal-fired power plant profile used was not well matched to the profile of the power plant actually affecting the park. A second possibility is that there exists a source of Se other than coal-fired power plants. The relationship between Centralia Power Plant emissions, a known source of Se and SO_2, and CMB results will be further examined in the next chapter with trajectory analysis.

The r^2 for the nitrate model is very low at 0.35 or 0.44 depending on whether a pulp and paper mill or transportation relative contribution is used in combination with the burn component. Use of all three sources together suggest collinearity between pulp and paper mills and transportation sources. The coefficients, presented in Tables 9-9 and 9-10, are significant. The model predicts that burning contributes about 30% to the measured nitrate, while either pulp and paper mill activity or transportation contributes about another 30%. Examination of Figure 9-6, which is a temporal plot of nitrates and relative burn and pulp and paper mill contributions, shows that for sampling period 38, the second highest nitrate level, corresponds to the highest value of burning contribution.

The model r^2 for organics and light-absorbing carbon are 0.52 and 0.80, respectively. Again, the sources contributing to these two species are transportation and burning activity. For both organics and light-absorbing carbon, transportation contributes about 60% of the measured values while burning contributes about 20%. These results are consistent with the interpretation of the empirical regression analysis. Referring to Figures 9-7 and 9-8 it can be seen that burning contributes significantly on sampling period 39, while on most other days transportation-related activity is the largest contributor to both organics and light-absorbing carbon at Paradise.

9.3 SUMMARY

The contribution of source types to visibility reducing aerosols was examined in two, not entirely independent, ways. First, CMB analysis was used to apportion the trace elements that were found to be associated with the various visibility reducing aerosols in the empirical regression analysis. Second, the relative contributions of each source type were used in a regression analysis in an attempt to directly apportion aerosols to sources. This analysis will be referred to as the CMB regression approach.

9.3.1 Tahoma Woods

The results of the sulfur apportionment are mixed. Both the empirical analysis and CMB regression approach show that coal-fired power plants are associated with sulfur. Taken together, the analysis suggests that between 10-20% of the measured sulfur is associated with coal-fired power plant emissions. However, the empirical approach suggests that transportation and burning are other sources of sulfur, while the CMB regression approach implicates only burning and not transportation as sources of elevated sulfur levels.

Table 9-9. Paradise: The first part of this table are the results of an OLS regression using ammonium nitrate as the dependent variable and the relative source strengths of pulp and paper mills, and burning as independent variables. The second half of the table, part b, presents the estimated nitrate mass associated with each source type along with the fraction of nitrates attributed to each source type. Units of elemental nitrates are µg/m^3.

a. Dependent variable = Nitrates, r^2 = 0.352

Variable	Est	Std Error	t-value	Prob t	Std Est	Cor with Dep Var
Constant	0.11	0.04	2.44	0.02	--	--
Kraft	0.002	0.001	2.23	0.03	0.27	0.21
Burn	0.002	0.001	4.69	0.00	0.56	0.53

b.

Variable	Mean	Std Dev	Variance	Minimum	Maximum	Fraction
Kraft	0.06	0.06	0.00	-0.00	0.24	0.25
Burn	0.07	0.10	0.01	0.00	0.80	0.31

Table 9-10. Paradise: The first part of this table are the results of an OLS regression using ammonium nitrate as the dependent variable and the relative source strengths of burning and transportation as independent variables. The second half of the table, part b, presents the estimated nitrate mass associated with each source type along with the fraction of nitrates attributed to each source type. Units of elemental nitrates are µg/m^3.

a. Dependent variable = Nitrates, r^2 = 0.444

Variable	Est	Std Error	t-value	Prob t	Std Est	Cor with Dep Var
Constant	0.04	0.05	0.70	0.49	--	--
Burn	0.00	0.00	4.92	0.00	0.59	0.54
Trans	0.04	0.01	3.28	0.00	0.40	0.32

b.

Variable	Mean	Std Dev	Variance	Minimum	Maximum	Fraction
Burn	0.08	0.11	0.04	0.00	0.86	0.38
Trans	0.09	0.09	0.00	0.00	0.31	0.36

Both analyses suggest that pulp and paper mill or lime kiln are the major source of nitrates. The estimates are between 20% and 50%. Burning, coal-fired power plants, and transportation are also shown to contribute to nitrates in the 10-20% range.

The suggested origins of organic and light-absorbing carbon are surprising. The statistical models are highly significant and both approaches suggest that most of the organics are associated with urban or transportation activity as opposed to being burn related. On the other hand, the CMB regression model suggests that about 70% of the light-absorbing carbon is burn related with a smaller fraction associated with transportation.

9.3.2 Paradise

At Paradise there is a strong statistical link between Se and sulfur and most Se is attributed to the coal-fired power plant signature. However, there is little or no correlation between the CMB predicted coal-fired power plant relative emissions and measured sulfur. Either the coal-fired power plant profile is not representative of the actual power plant emissions within the park or there is a significant source of Se that has not been included in the CMB analysis. The association of sulfur with known sources of sulfur and Se will be examined again in Chapter 10 using back trajectory analysis.

Tahoma Woods' nitrates are associated to some degree with all four source categories with the strongest statistical relationship between nitrates and Na. Most Na is linked to pulp and paper mill or lime kiln activity.

Organics and light-absorbing carbon are split at about a 60-70% to 20-30% (See Tables 9-11 and 9-12) ratio between transportation and burning activity. Interestingly, transportation appears to be responsible for most of the organics and light-absorbing carbon.

Table 9-11. Paradise: The first part of this table are the results of an OLS regression using organics as the dependent variable and the relative source strengths of transportation and burning as independent variables. The second half of the table, part b, presents the estimated organic mass associated with each source type along with the fraction of organics attributed to each source type. Units of elemental organics are μg/m^3.

a. Dependent variable = Organics, r^2 = 0.525

Variable	Est	Std Error	t-value	Prob t	Std Est	Cor with Dep Var
Constant	0.30	0.40	0.76	0.45	--	--
Trans	0.47	0.08	5.80	0.00	0.65	0.59
Burn	0.01	0.00	3.84	0.00	0.43	0.34

b.

Variable	Mean	Std Dev	Variance	Minimum	Maximum	Fraction
Trans	1.26	1.20	1.44	0.00	4.54	0.62
Burn	0.46	0.66	0.43	0.00	5.10	0.23

Table 9-12. Paradise: The first part of this table are the results of an OLS regression using light absorbing carbon as the dependent variable and the relative source strengths of transportation and burning as independent variables. The second half of the table, part b, presents the estimated light absorbing carbon mass associated with each source type along with the fraction of light absorbing carbon attributed to each source type. Units of elemental light absorbing carbon are μg/m^3.

a. Dependent variable = Carbon, r^2 = 0.794

Variable	Est	Std Error	t-value	Prob t	Std Est	Cor with Dep Var
Constant	0.01	0.04	0.37	0.71	--	--
Trans	0.08	0.01	10.69	0.00	0.78	0.71
Burn	0.00	0.00	7.44	0.00	0.55	0.44

b.

Variable	Mean	Std Dev	Variance	Minimum	Maximum	Fraction
Trans	0.21	0.20	0.04	0.00	0.78	0.67
Burn	0.08	0.12	0.01	0.00	0.91	0.26