

## **APPENDIX A**

### **Results of Preliminary Model Sensitivity Simulations**

## Model Sensitivity Results for 2002

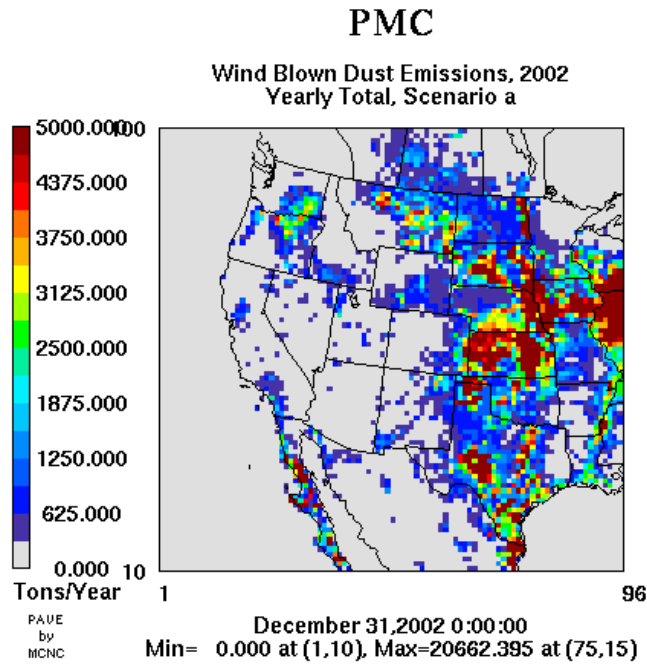
The revised windblown dust emission model was run using the estimation methodologies and data described above. A total of four scenarios were conducted to evaluate the sensitivity of the model to the various assumptions incorporated in the methodology. The four scenarios were designed to consider the effects of soil disturbance and reservoir characteristics. These scenarios were as follows:

- a. No limitation on dust event duration; all soils loose and undisturbed
- b. Dust event duration limited to 10 hours per day; all soils loose and undisturbed
- c. No limitation on dust event duration for disturbed or undisturbed soils; 10% of grassland, shrubland, and barren land area assumed disturbed; threshold friction velocity for disturbed grass and shrubland =  $0.5 \cdot (\text{undisturbed value})$ ; threshold friction velocity for barren land =  $0.27 \cdot (\text{undisturbed value})$
- d. Dust event duration limited to 10 hours per day for undisturbed soils; no limitation on dust event duration for disturbed soils; 10% of grassland, shrubland and barren land area assumed disturbed; threshold friction velocity for disturbed grass and shrubland =  $0.5 \cdot (\text{undisturbed value})$ ; threshold friction velocity for barren land =  $0.27 \cdot (\text{undisturbed value})$

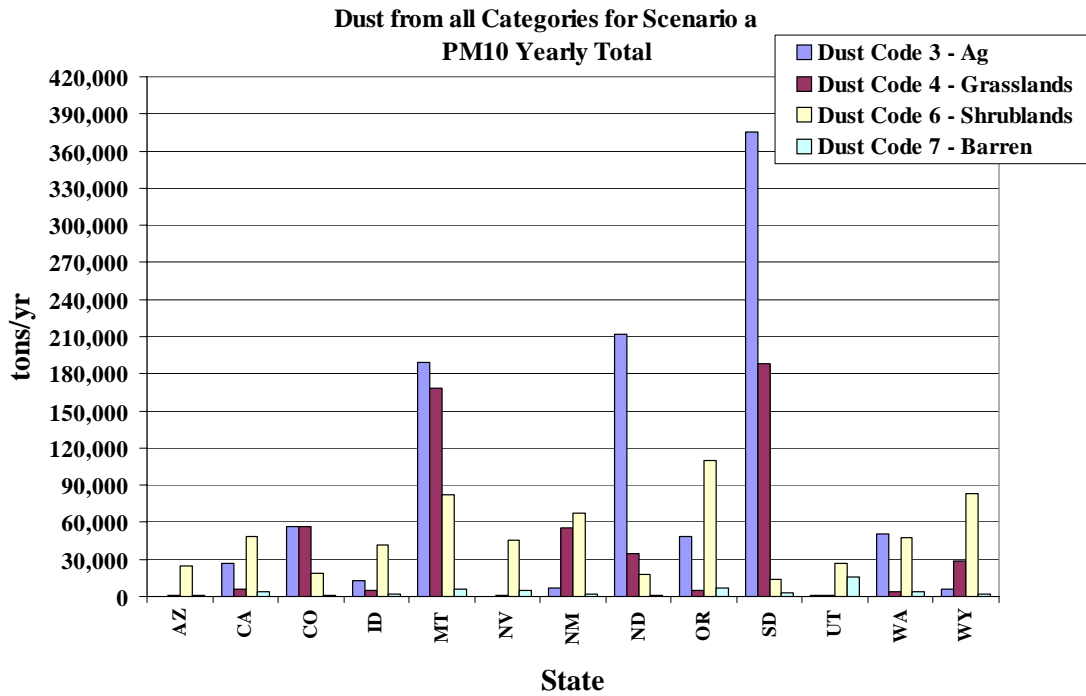
This section presents plots of coarse PM (PMC) and  $PM_{10}$  for each scenario. In addition, the results of each scenario are discussed and compared. Recommendations regarding which scenario is most appropriate for further evaluation and air quality modeling are also made. Displays of the spatial distribution of dust emissions are presented in terms of PMC while state-level and domain-wide results are presented in terms of  $PM_{10}$ . Spatial displays are generated from the gridded model-ready emission files, which represent PMC as required by the air quality models.  $PM_{10}$  emission estimates are available as text files output directly from the dust model and are summarized by land type and/or state for presentation.

### Scenario a

Scenario a considered all soils to be loose and undisturbed. In addition, no limit on the duration of dust events was imposed. The spatial distribution of PMC emissions is displayed in Figure A-1. Figure A-2 shows the distribution of predicted  $PM_{10}$  dust emissions by land use type for each of the WRAP states.



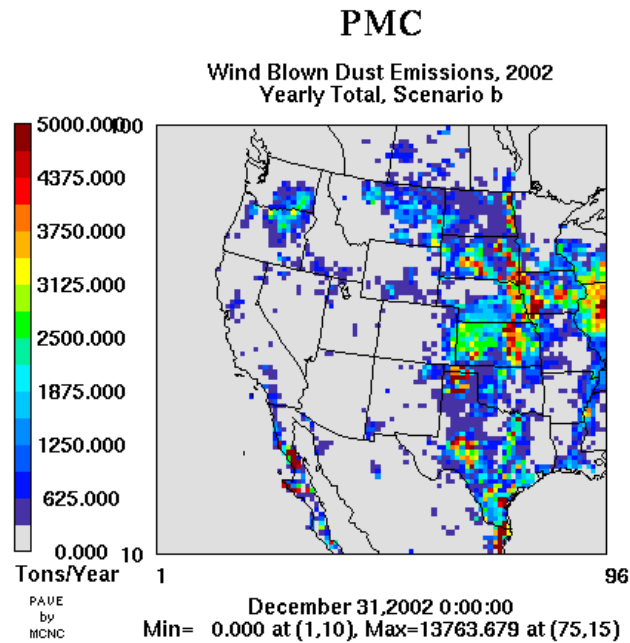
**Figure A-1.** Spatial distribution of total 2002 annual PMC dust emissions for Scenario a.



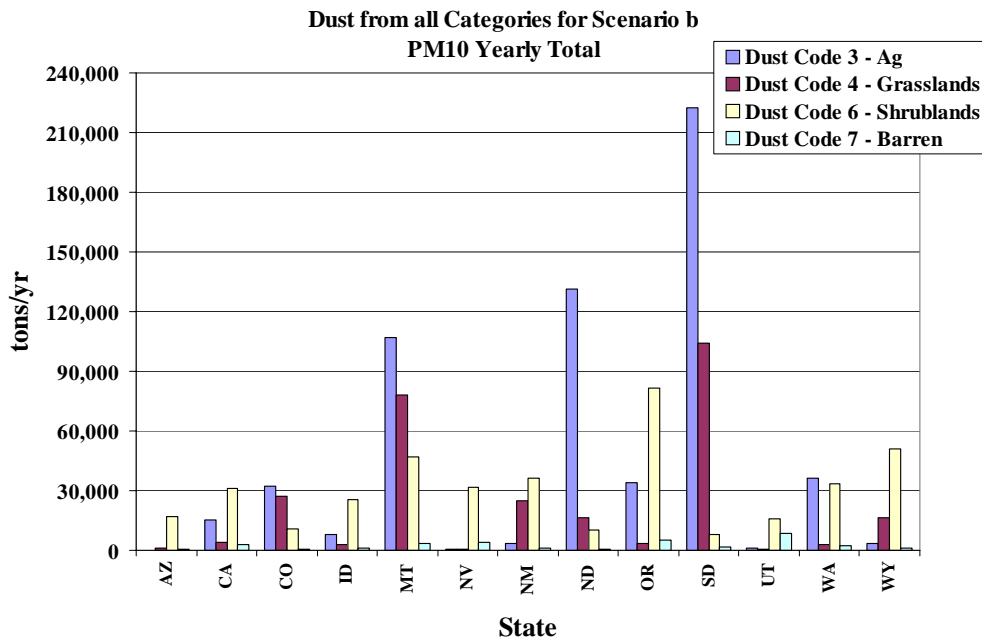
**Figure A-2.** Distribution of total annual 2002 PM<sub>10</sub> dust emissions by land use type and state for Scenario a.

Scenario b

As in Scenario a, Scenario b considered all soils to be loose and undisturbed. In contrast to Scenario a, however, the duration of dust events was limited to 10 hours per day. Figure A-3 shows the spatial distribution of PMC emissions. The distribution of predicted PM<sub>10</sub> dust emissions by land use type for each of the WRAP states is displayed in Figure A-4.



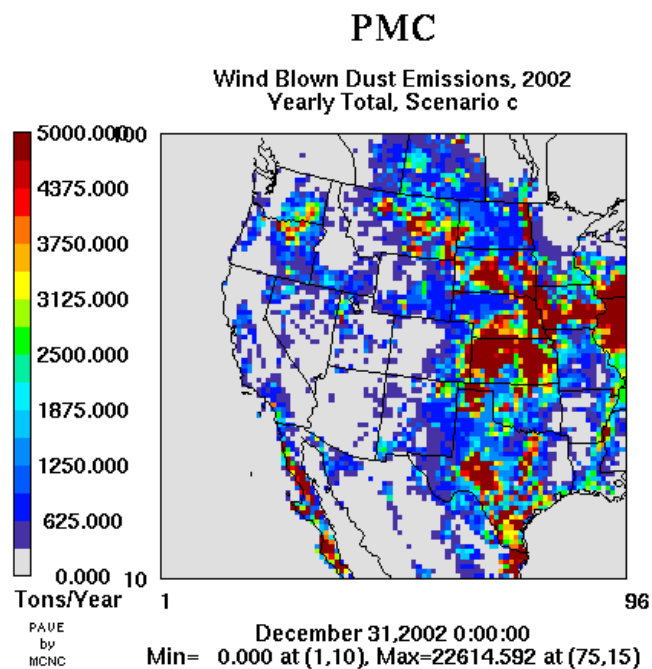
**Figure A-3.** Spatial distribution of total 2002 annual PMC dust emissions for Scenario b.



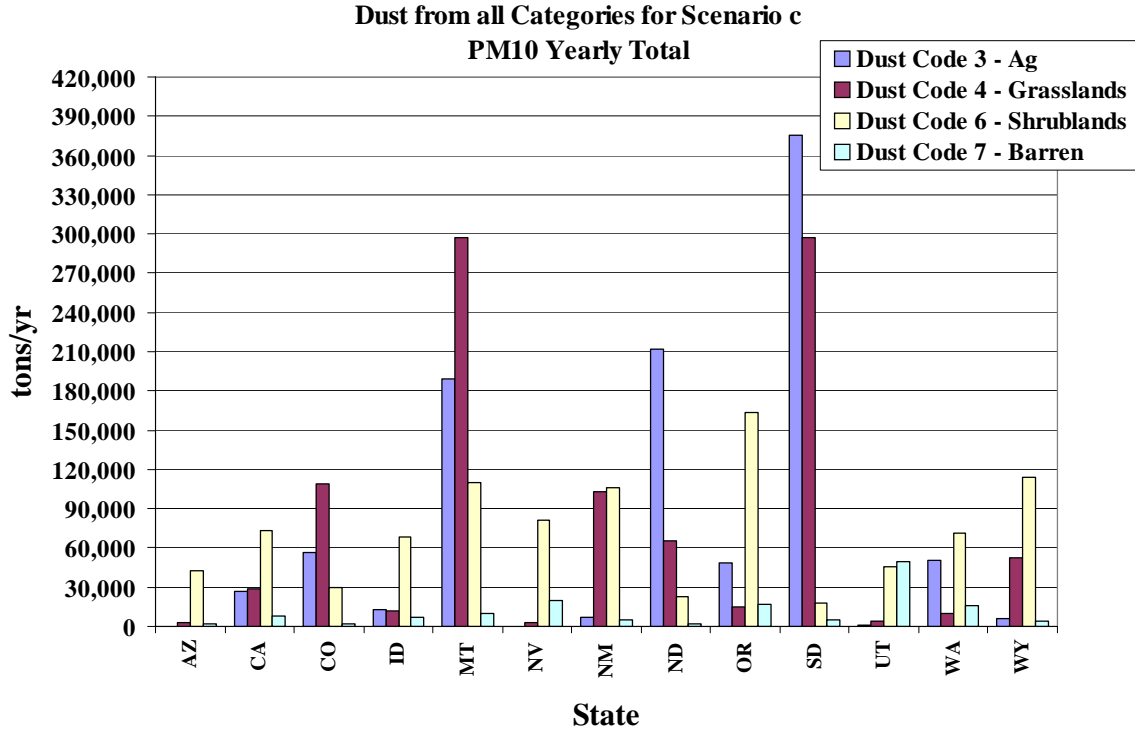
**Figure A-4.** Distribution of total annual 2002 PM<sub>10</sub> dust emissions by land use type and state for Scenario b.

Scenario c

Scenario c assumed that 10% of the grassland, shrubland, and barren land area was disturbed. For the disturbed areas, threshold friction velocities were reduced, resulting in the initiation of wind erosion at lower wind speeds. For disturbed grassland and shrubland the threshold friction velocity was assumed equal to 0.5 times the undisturbed value; for disturbed barren land the threshold friction velocity was assumed equal to 0.27 times the undisturbed value. In addition, no limit on the duration of dust events was imposed for either disturbed or undisturbed soils. The spatial distribution of PMC emissions is displayed in Figure A-5, while Figure A-6 shows the distribution of predicted PM<sub>10</sub> dust emissions by land use type for each WRAP state.



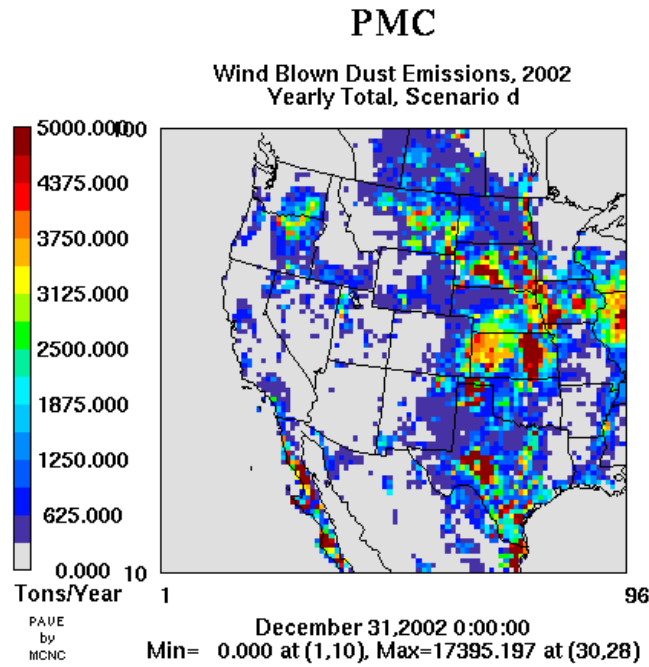
**Figure A-5.** Spatial distribution of total 2002 annual PMC dust emissions for Scenario c.



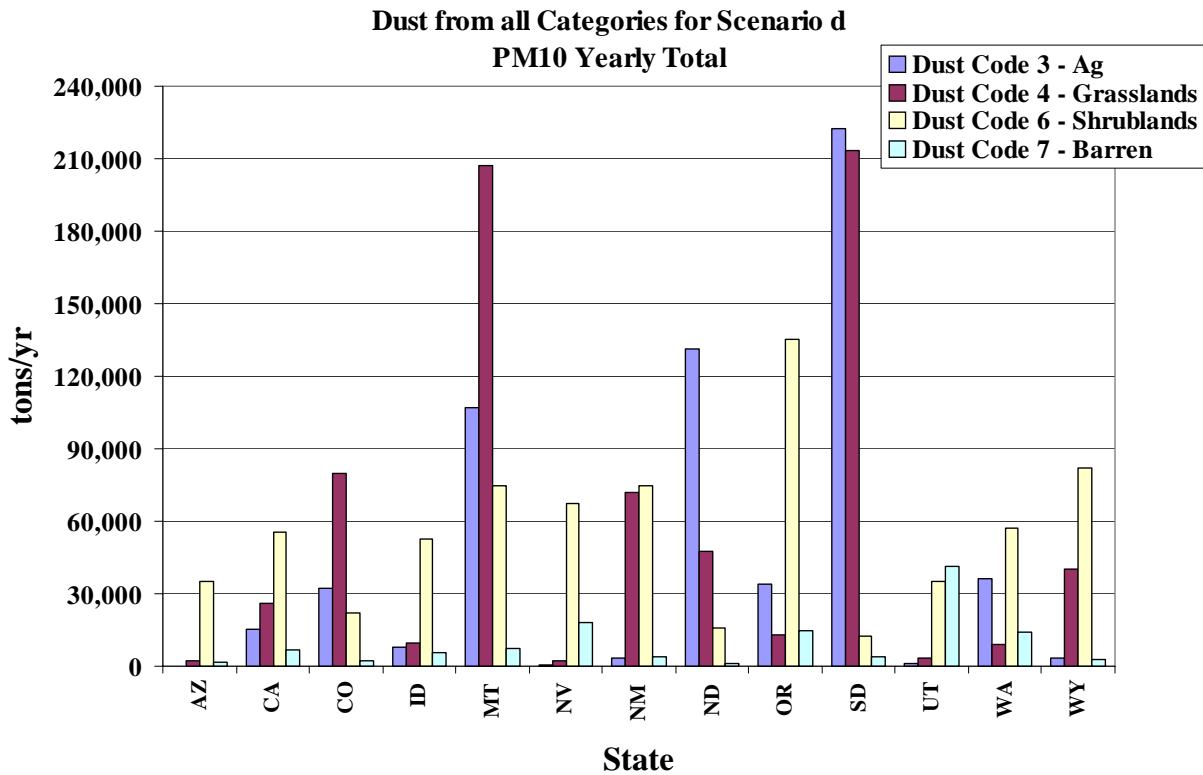
**Figure A-6.** Distribution of total annual 2002 PM<sub>10</sub> dust emissions by land use type and state for Scenario c.

Scenario d

Scenario d made the same assumption as Scenario c concerning the disturbance of grassland, shrubland, and barren land. However, a 10-hour-per-day limit on dust event duration was imposed for all undisturbed soils while no limit on the dust event duration is imposed for disturbed soils. This scenario differs from Scenario c in that no limit on the event duration is imposed for either disturbed or undisturbed soils in Scenario c. Figure A-7 shows the spatial distribution of PMC emissions. The distribution of predicted PM<sub>10</sub> dust emissions by land use type and WRAP state is displayed in Figure A-8.



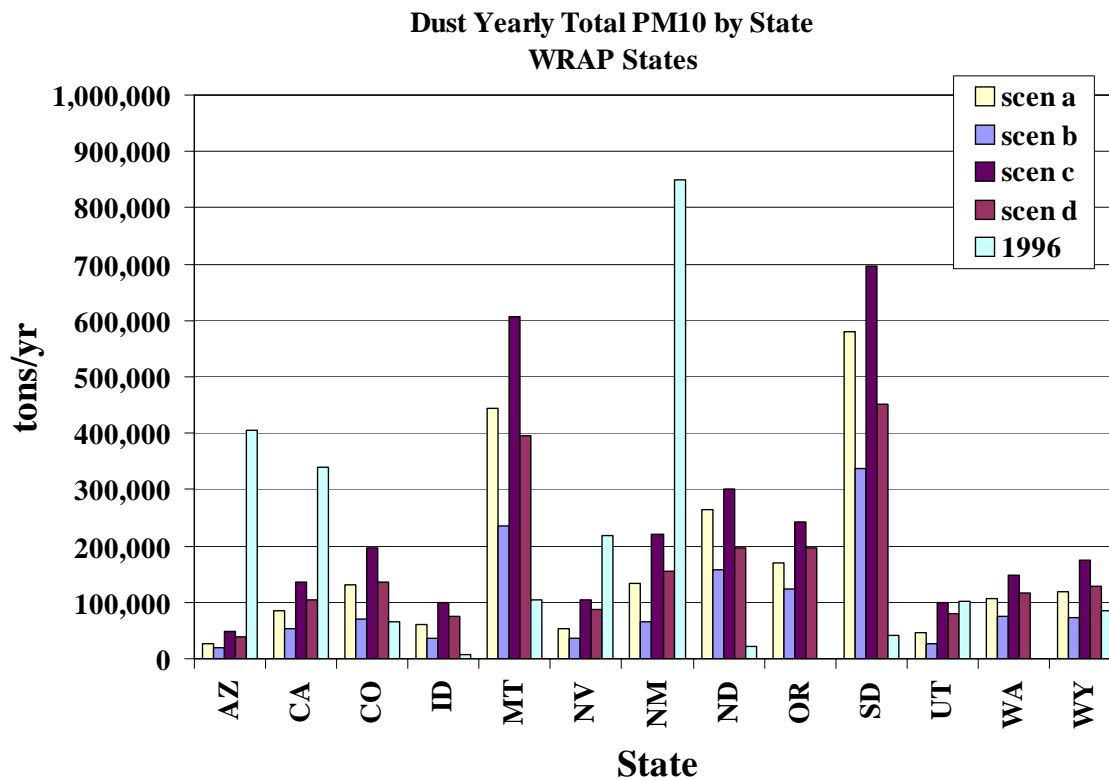
**Figure A-7.** Spatial distribution of total 2002 annual PMC dust emissions for Scenario d.



**Figure A-8.** Distribution of total annual 2002 PM<sub>10</sub> dust emissions by land use type and state for Scenario d.

## Summary and Comparison of Results

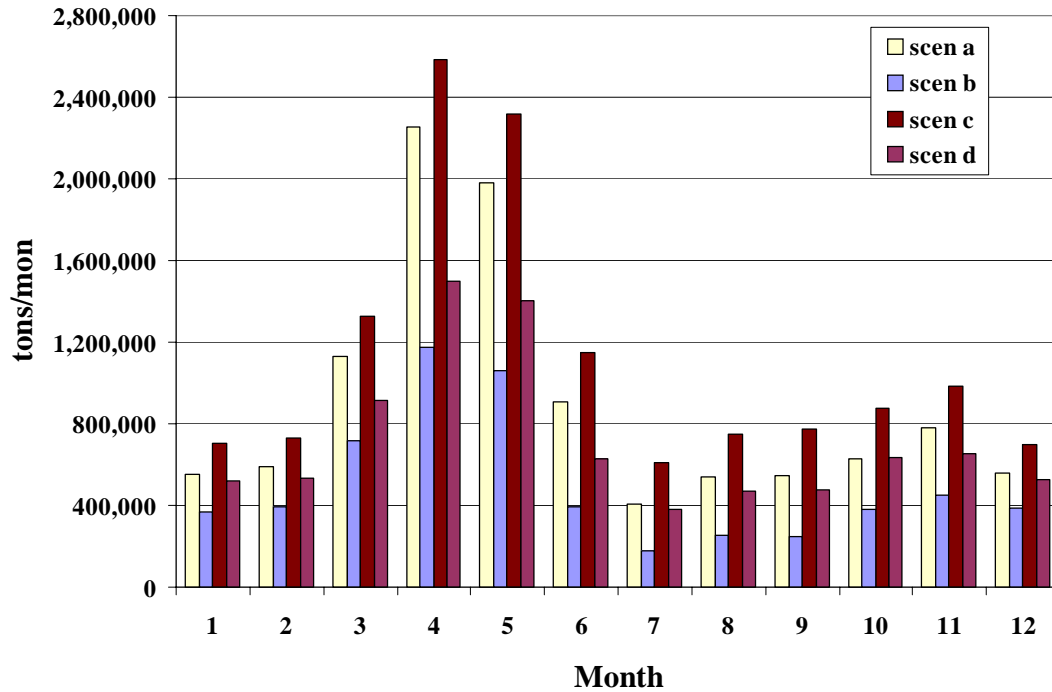
The results of the four sensitivity simulations are compared below. Figure A-9 compares the total annual 2002 PM<sub>10</sub> dust emissions for the four scenarios by WRAP state. Also displayed are the total annual PM<sub>10</sub> dust emissions for 1996 estimated as part of the Phase I Windblown Dust Project. Figure A-10 shows the monthly distribution of total PM<sub>10</sub> for the entire domain for the four scenarios. The emissions for Scenarios a and c (no limitation on dust event duration) are consistently higher than those from their counterparts, Scenarios b and d (dust event duration limited to 10 hours a day). This result is expected, since the lack of limitation on dust events causes higher emissions to be generated in regions where winds exceed the land-use-dependent threshold surface velocities for longer time periods. Also as expected, the cases with assumed disturbance of grassland, shrubland, and barren land (Scenarios c and d) show consistently higher emissions than those with no assumed soil disturbance (Scenarios a and b).



**Figure A-9.** Distribution of total annual 2002 PM<sub>10</sub> dust emissions by scenario and state.

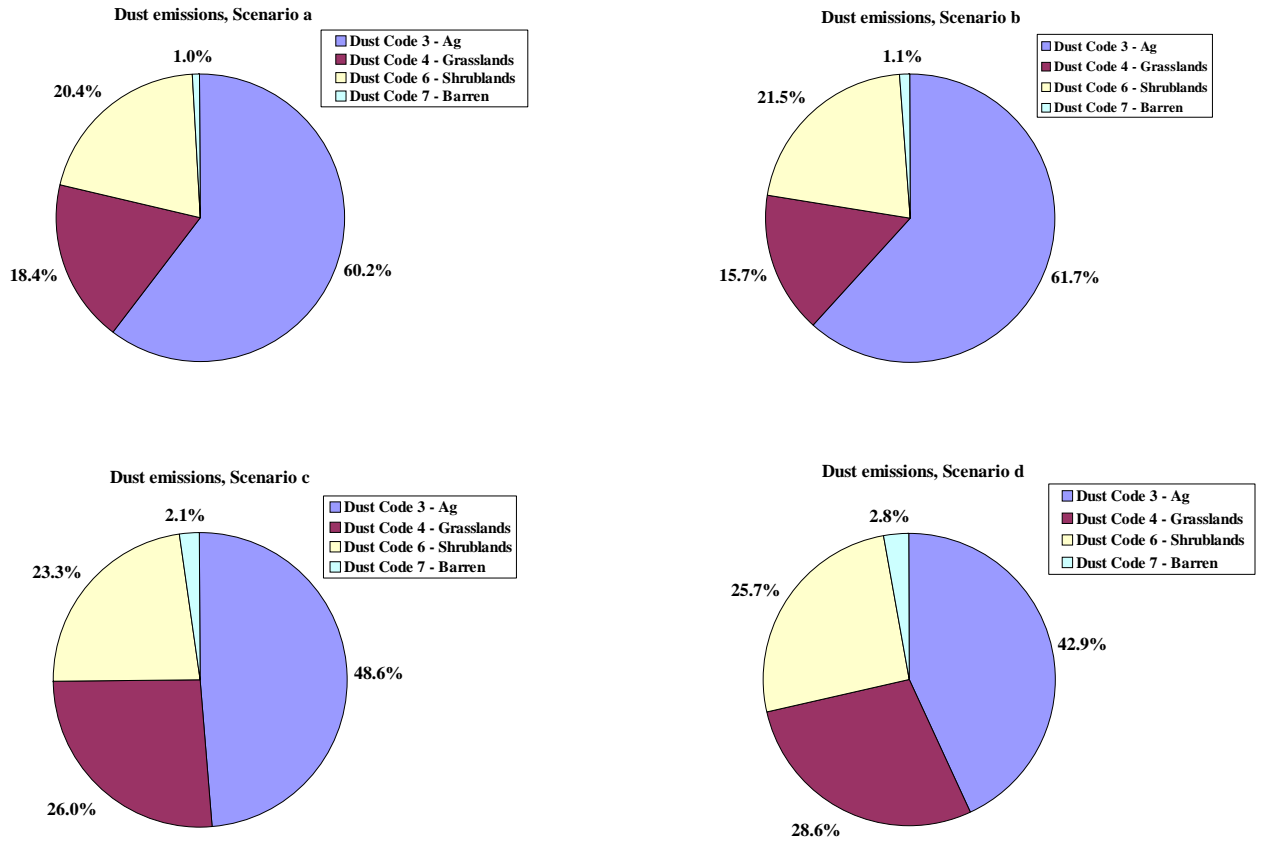
The seasonal variation of predicted dust emissions can also be discerned from Figure A-10. The dust emissions tend to peak in the spring months due to generally higher winds throughout most of the domain. In addition, for agricultural areas this time period corresponds to the spring planting when the crop canopy is relative small or absent. A second, smaller peak occurs in the fall for similar reasons.

### Monthly Dust Emissions for the Entire Domain



**Figure A-10.** Monthly distribution of total 2002 PM<sub>10</sub> dust emissions for each scenario across the entire domain.

Figure A-11 displays the percentage of dust by land use type across the WRAP domain for each scenario. In all cases, the dust emissions are dominated by those from agricultural lands. Shrubland and grassland make up the majority of the remaining dust emissions, while barren land contribute only a minor portion. Although barren lands have the lowest surface threshold velocity based on the assumed surface roughness length, there are only limited areas across the domain characterized as barren lands based on the NLCD used for the project. The impact of the various assumed disturbance levels of the soils and reservoir characteristics are reflected in the differences between the four pie charts and are seen to be consistent with expectations.



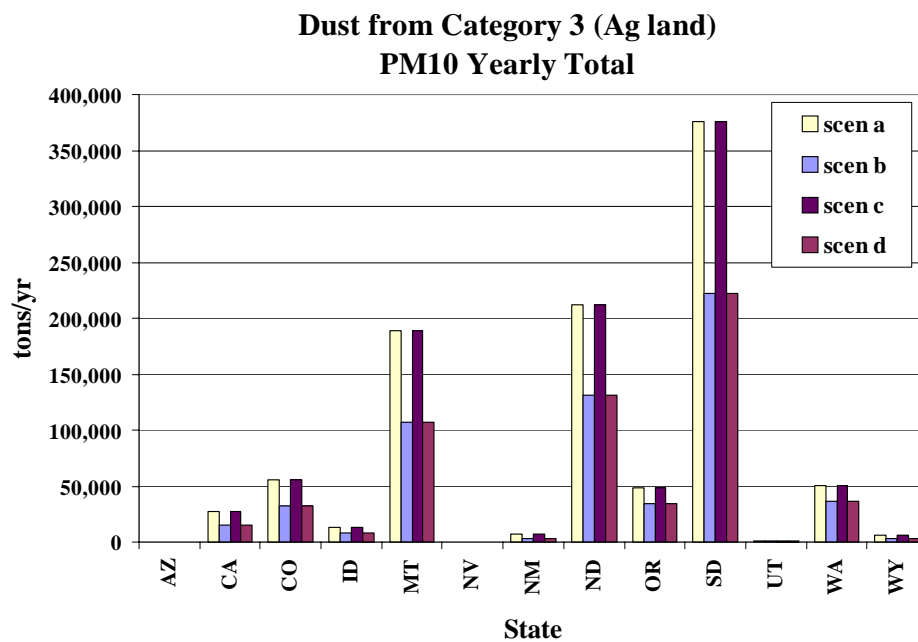
**Figure A-11.** Distribution of total 2002 PM<sub>10</sub> dust emissions by land use type for each scenario for all WRAP states combined.

Table 4-1 presents the total PM<sub>10</sub> dust emission across the US portion of the modeling domain and WRAP states alone. The 1996 estimates are those developed during Phase I of the Windblown Dust Project. It should be noted that for the 1996 results, the US portion of the modeling domain is smaller than that for the 2002 results. The Phase I modeling domain extended to just east of the Mississippi River.

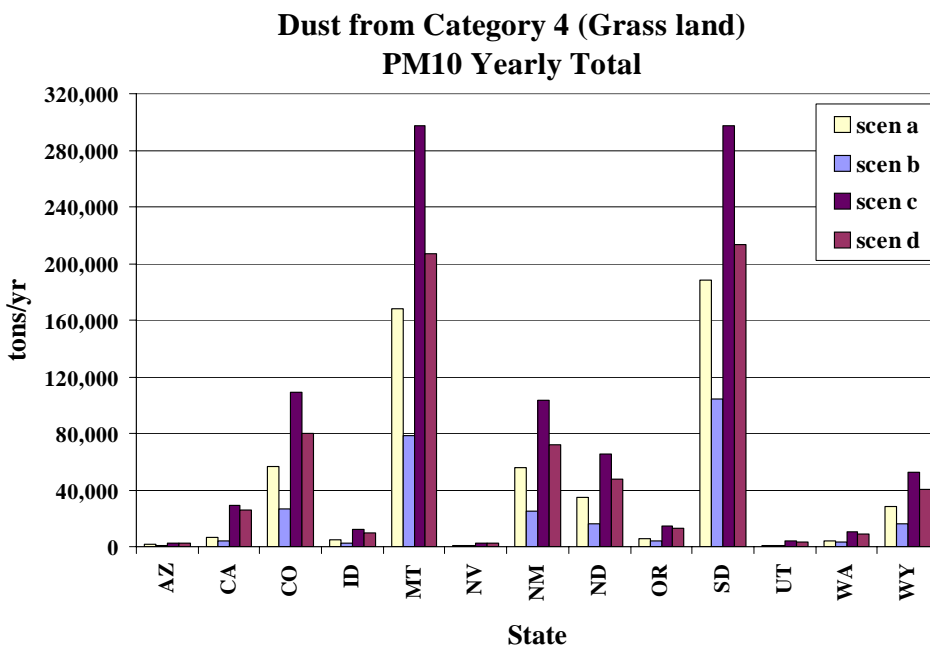
**Table 4-1.** Comparison of estimated PM<sub>10</sub> dust emission for each 2002 scenario and the Phase I 1996 model estimates (tons/yr).

Scenario	WRAP States	Domain Total (US portion only)
a	2,222,219	9,451,368
b	1,310,120	5,228,818
c	3,077,196	11,098,731
d	2,165,096	6,876,180
1996 (Phase I)	2,240,288	4,366,907

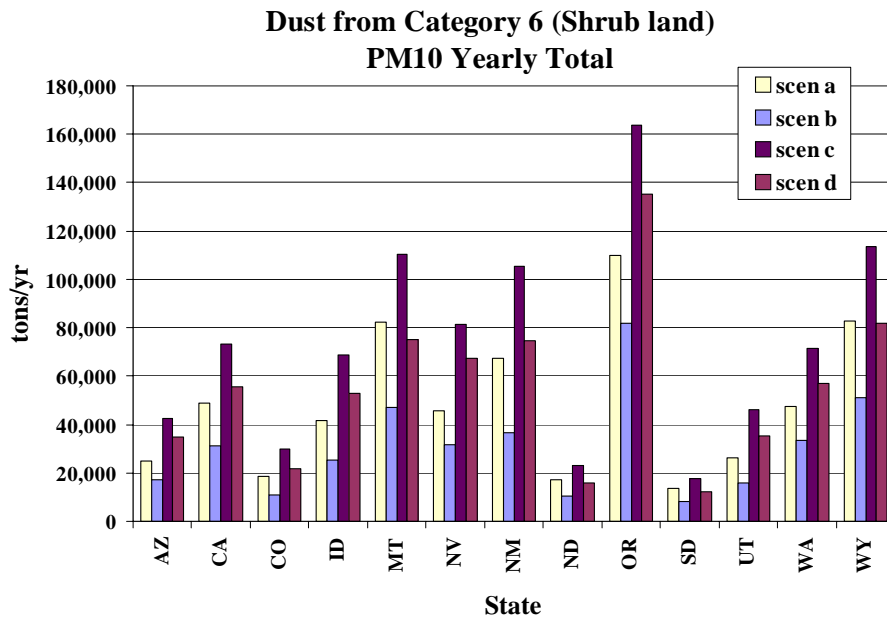
Comparisons of the estimated dust emission for each scenario by land use category are presented in Figures 4-12 through 4-15.



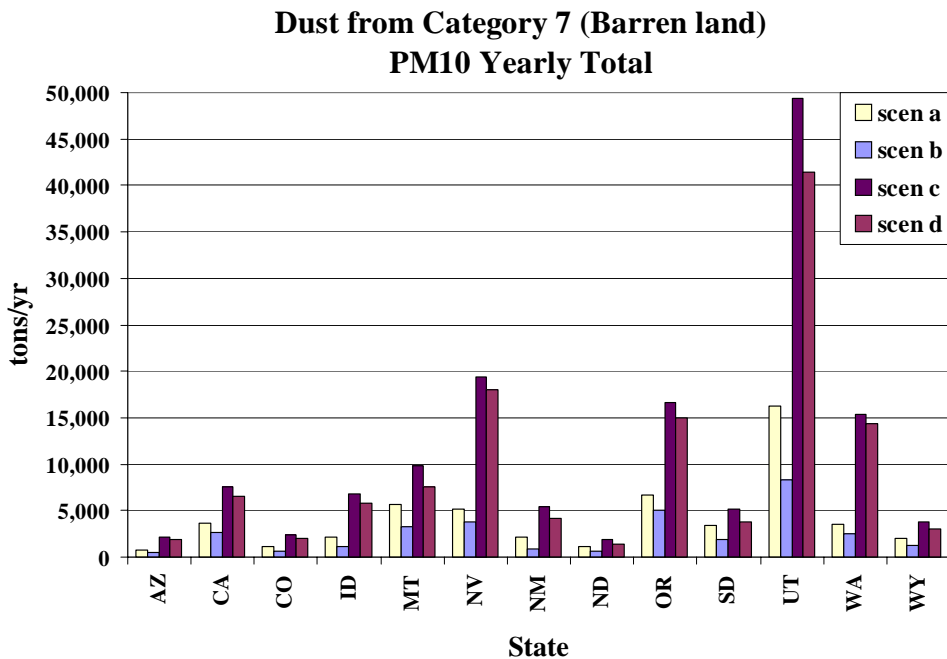
**Figure A-12.** Annual PM<sub>10</sub> dust emissions from agricultural lands for the WRAP states by scenario.



**Figure A-13.** Annual PM<sub>10</sub> dust emissions from grasslands for the WRAP states by scenario.



**Figure A-14.** Annual PM<sub>10</sub> dust emissions from shrublands for the WRAP states by scenario.



**Figure A-15.** Annual PM<sub>10</sub> dust emissions from barren lands for the WRAP states by scenario.

Based on review and comparison of the results of the sensitivity simulations, we recommend that the results of Scenario b be used for further evaluation and air quality modeling. Scenario b assumes that all soils are loose and undisturbed, and imposes a 10-hour-per-day limit on the duration of dust events. Given the limitations of the data used for this task, this scenario appears to be the most appropriate.

- *Dust Event Duration:* It is reasonable to expect that a limit on the dust event duration is related to the type and amount of spoil available for erosion due to winds. Therefore, the

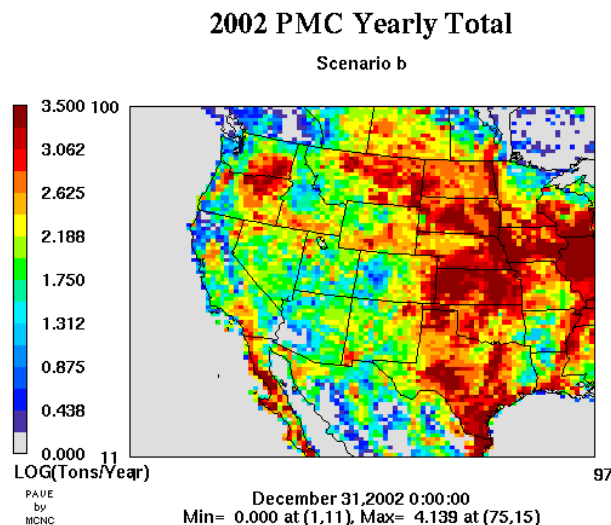
assumed limit of 10 hours per day, although only an assumption, is more appropriate than imposing no limit at all on the dust reservoirs.

- *Soil Disturbance:* Although clearly not all soils are undisturbed, there is no information available to assign disturbance levels to various areas throughout the region. Scenarios c and d assumed a 10% level of disturbance, but that was only for conducting sensitivity simulations. Clearly the percent disturbance will vary by region, soils type, and season. In addition, the threshold surface velocities for the disturbed soil cases are based on only very limited test results and are therefore not likely to apply region-wide.

Given the lack of supporting data for the dust reservoir and soil disturbance characteristics, we felt that the results of Scenario b would be more universally applicable on a regional scale for the WRAP's air quality modeling purposes.

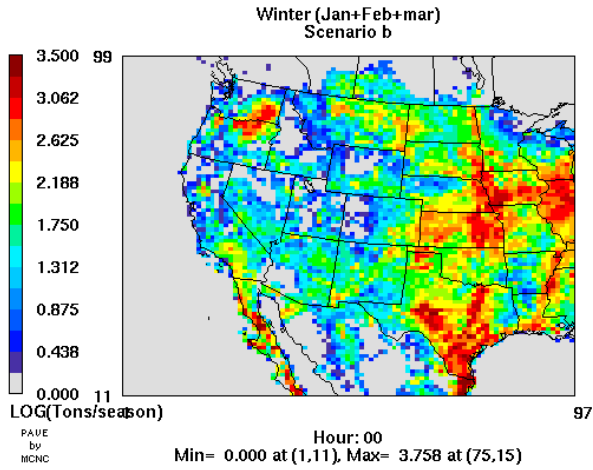
The spatial distributions of modeled coarse PM dust from Scenario b are presented in Figures A-16 (annual total) and A-17 (seasonal totals). Note that these figures show only the western portion of the domain. Due to the lack of detailed agricultural information for states outside the WRAP and CENRAP regions, we could not apply the nonclimatic agricultural adjustments described above outside those two regions. Because the assumed surface roughness for agricultural lands is representative of a bare field, these areas have a greater potential for wind erosion. Therefore, since no agricultural adjustment could be applied to the eastern portion of the domain, results for that region are overestimated and are therefore neither realistic nor applicable. The displays were prepared for the western region only in order to highlight spatial details not apparent when the entire domain is displayed.

The dust emissions are highest in agricultural areas in the central portion of the U.S. and in parts of the West that are dominated by shrub- and grassland. Echoing the results shown in Figure A-16, the seasonal plots in Figure A-17 indicate that the highest predicted dust emission occur during the spring, when winds are typically stronger throughout the region and agricultural crops have recently been planted. Lower overall dust emissions are predicted in the summer months, corresponding to the higher level of crop canopy cover and, in the Southwest, to increased periods of precipitation.

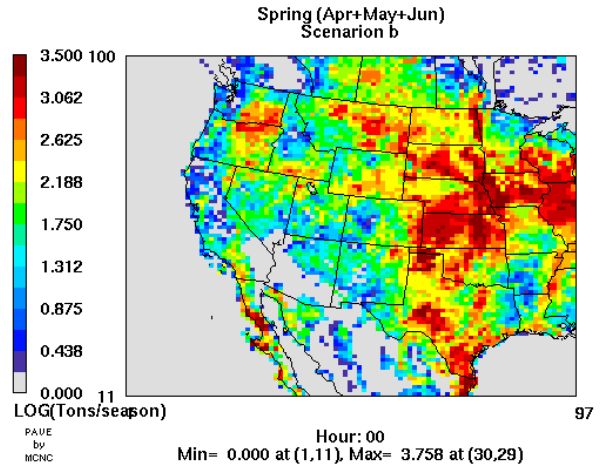


**Figure A-16.** Spatial distribution of 2002 PMC dust emissions for scenario b.

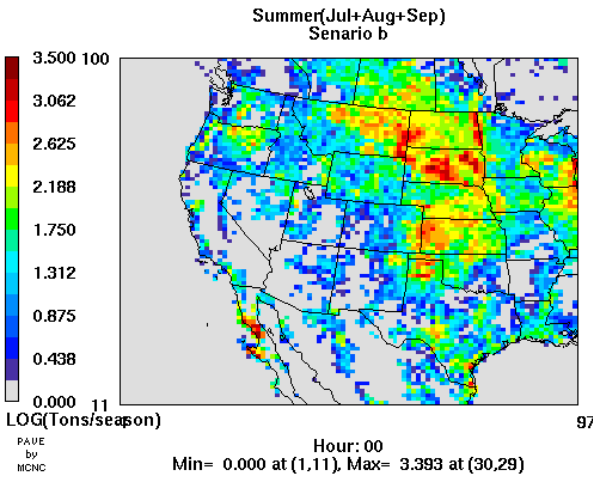
### 2002 PMC Total Seasonal Emissions



### 2002PMC Total Seasonla Emissions



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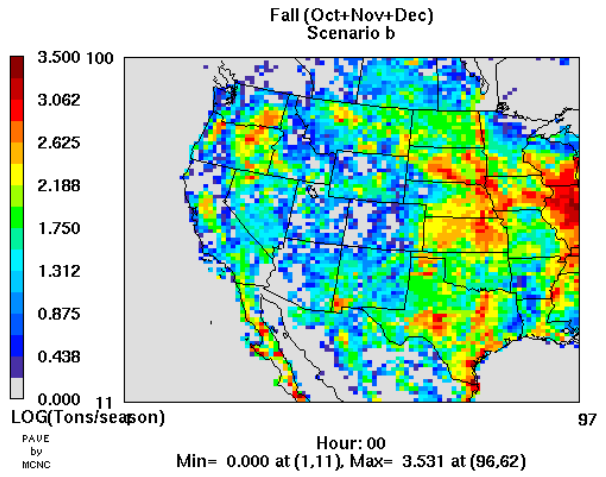


Figure A-17. Spatial distribution of 2002 PMC dust emissions by season for Scenario b.