

LESSON 5

Monitoring Planning Areas and Community Monitoring Zones

Goal

To familiarize you with available data and data analysis techniques used to define metropolitan planning areas and community monitoring zones.

Objectives

After completion of this lesson you should be able to:

1. evaluate spatially-defined populated entities, source emissions inventories, meteorological data, and terrain variations that can be aggregated to define monitoring planning areas and community monitoring zones.
2. apply spatial uniformity measures to historic particle measurements and define the zone of representation for existing particle samplers.
3. assign priorities to new $PM_{2.5}$ monitoring station locations and to the reduction of existing PM_{10} monitoring station locations based on objective and defensible criteria.

Reading Assignment Topics

- Monitoring Planning Areas
- Community Monitoring Zones

Procedure

1. Read sections 2.3.2 (pg. 2-18 through 2-19), 3.0 through 3.5 (pg. 3-1 through 3-20) and 4.0 through 4.5 (pages 4-1 through 4-9) of *Guidance for the Network Design and Optimum Site Exposure for $PM_{2.5}$ and PM_{10}* .
2. Complete the review exercises.
3. Check your answers using the answer key in Appendix A.
4. Review the pages from any material you missed.
5. Continue to Lesson 6

Review Exercise

1. What are the 4 steps for defining a MPA?
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2. True or false? MSAs are useful for defining the boundaries of MPAs.
 - a. True
 - b. False

3. The San Joaquin Valley has a very high potential for transport of PM. Which of the following provides one of the reasons?
 - a. Bare land is prevalent throughout the region.
 - b. The area possesses a great number of unpaved roads.
 - c. The average temperature is warm.
 - d. The area is significantly affected by periodic El Nino effects.

4. List the 5 steps for designating CMZ and core sites.
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5. It is critical to determine spatial homogeneity in
 - a. designating MPAs.
 - b. designating CMZs.
 - c. Both a and b
 - d. Neither a nor b

6. Computer modeling estimates of $PM_{2.5}$ may not accurately represent reality. Why not?
 - a. Secondary particle formation depends on often unknown factors.
 - b. Emission rates from area and mobile sources are often inaccurate.
 - c. Transport under low wind-speed conditions is not well measured or modeled.
 - d. All of the above

7. If an existing site within a CMZ does not meet the criteria for neighborhood or urban zones of representation, _____
 - a. the monitor cannot be used to determine compliance and must be removed.
 - b. the monitor can still be used for compliance with the 24-hour standard, but not for compliance with the annual standard or for spatial averaging.
 - c. the monitor can still function as a background site.
 - d. the monitor cannot be used to determine daily compliance, but can be used as a special purpose monitor site.

8. True or false? If a PAMS station is located in a CMZ and attains the neighborhood or urban criteria, it should be selected as the first monitor in the CMZ.
 - a. True
 - b. False

9. The second site to be added to the CMZ is one of high population and poor air quality. In this case, _____ should be given prime consideration.
- a. existing SLAMS sites
 - b. existing PM_{10} NAMS sites
 - c. existing PM_{10} sites of any type
 - d. a site with a continuous fine particle analyzer

Required Readings

- **Error Per Cost (EPC) (Borgman *et al.*, 1996):** This is the reciprocal of CPE. It quantifies the statistical uncertainty associated with a given amount of monitoring resources.

2.3.2 Monitoring Boundaries

The new standards refer to several boundaries. Metropolitan Statistical Areas, Primary Metropolitan Statistical Areas, Consolidated Metropolitan Statistical Areas, and New England County Metropolitan Areas are defined by the U.S. Office of Management and Budget, and these are defined in Appendix B for the 1990 census. Metropolitan Planning Areas and Community Monitoring Zones are areas with boundaries corresponding to subdivisions of the statistical areas that are to be defined by each state according to these guidelines.

- **Metropolitan Statistical Area (MSA):** MSAs are designated by the U.S. Office of Management and Budget (OMB) as having a large population nucleus, together with adjacent communities having a high degree of economic and social integration with that nucleus. MSA boundaries correspond to portions of counties, single counties or groups of counties that often include urban and non-urban areas. MSAs are useful for identifying which parts of a state have sufficient populations to justify the installation of a compliance monitoring network. Their geographical extents may be too big for defining the boundaries of Metropolitan Planning Areas and Community Monitoring Zones.
- **Primary Metropolitan Statistical Area (PMSA):** PMSAs are single counties or groups of counties that are the component metropolitan portions of a mega-metropolitan area. PMSAs are similar to MSAs with the additional characteristic of having a degree of integration with surrounding metropolitan areas. A group of PMSAs having significant interaction with each other are termed a Consolidated Metropolitan Statistical Area (CMSA).
- **Consolidated Metropolitan Statistical Area (CMSA):** A Consolidated Metropolitan Statistical Area (CMSA) is a group of metropolitan areas (PMSAs) that have significant economic and social integration.
- **New England County Metropolitan Statistical Area (NECMSA):** The OMB defines NECMAs as a county-based alternative for the city- and town-based New England MSAs and CMSAs. The NECMA defined for an MSA or CMSA includes:
 - The county containing the first-named city in that MSA/CMSA title (this county may include the first-named cities of other MSAs/CMSAs as well), and
 - Each additional county having at least half its population in the MSAs/CMSAs whose first-named cities are in the previously identified county. NECMAs are not identified for individual PMSAs. There are twelve

NECMAs, including one for the Boston-Worcester-Lawrence, MA-NH-ME-CT CMSA and one for the Connecticut portion of the New York-Northern New Jersey-Long Island, NY-NJ-CT-PA CMSA.

- **Monitoring Planning Area (MPA):** MPAs are defined by the state implementation plan as the basic planning unit for $PM_{2.5}$ monitoring. A MPA is a contiguous geographic area with established, well-defined boundaries. MPAs may cross state lines and can be further subdivided into Community Monitoring Zones. A MPA does not necessarily correspond to the boundaries within which pollution control strategies will be applied. In fact, it is expected that emissions control regions will be much larger than the MPAs, owing to the superposition of regional-, urban-, and neighborhood-scale contributions to $PM_{2.5}$. MPAs may include aggregates of: 1) counties; 2) zip code regions; 3) census blocks and tracts; or 4) established air quality management districts. Counties are often much larger than the most densely populated areas they contain, and some large metropolitan areas may extend over several counties. Census blocks are very small and may be unwieldy to manipulate in some large areas. Zip code and census tract boundaries may be the most manageable units for many areas. These boundaries vary substantially in geography from one region to another. MPAs normally will contain at least 200,000 people, though portions of a state not associated with MSAs can be considered as a single MPA. Optional MPAs may be designated for other areas of a state. MPAs in MSAs are completely covered by one or more Community Monitoring Zones.
- **Community Monitoring Zone (CMZ):** When spatial averaging is utilized for making comparisons to the annual $PM_{2.5}$ NAAQS, Community Monitoring Zones must be defined in the monitoring network description. Otherwise, they may be used as a more informal manner, as a means to describe the communities surrounding one or more core monitoring sites. CMZs have dimensions of 4 to 50 km with boundaries defined by existing political demarcations (e.g., aggregates of zip codes, census tracts) with population attributes. They could be smaller in densely populated areas with large pollutant gradients. Each CMZ would ideally equal the collective zone of representation of one or more community-oriented monitors within that zone. The CMZ, applicable only to $PM_{2.5}$, is intended to represent the spatial uniformity of $PM_{2.5}$ concentrations. In practice, more than one monitor may be needed within each CMZ to evaluate the spatial uniformity of $PM_{2.5}$ concentrations and to accurately calculate the spatial average for comparison with the annual $PM_{2.5}$ NAAQS. When spatial averaging is used, each MPA would be completely covered by one or more contiguous CMZs.

2.3.3 Monitoring Networks

$PM_{2.5}$ monitoring networks may be new networks or part of existing networks. Additional sites may be added to existing networks according to this guidance.

3.0 DEFINING STATE PLANNING AREAS

This section specifies the steps to define the boundaries of Monitoring Planning Areas (MPAs) for determining compliance with PM_{10} and $PM_{2.5}$ standards. This procedure requires the spatial examination of population statistics, topography, existing PM networks, past measurements, emissions densities, pollution transport patterns, and existing planning areas. The procedure gives preference to maintaining existing planning areas as MPAs for $PM_{2.5}$ and for adapting existing sites to $PM_{2.5}$ compliance monitoring. It also provides an objective means for identifying PM_{10} measurement locations that can be discontinued as PM_{10} compliance monitors.

Two examples, from Birmingham and Jefferson County, AL, and from California's San Joaquin Valley, are used to illustrate the application of the approach for selecting MPAs, optional CMZs, and sampling sites. These eastern and western areas show several examples of complications and solutions that might be encountered in following these guidelines. These examples are given for illustrative purposes only, using data from the public domain obtained from the sources identified in Appendix A. It is not intended that these examples should be used as the basis for re-design of existing PM networks in either of these areas.

The following steps define the MPAs:

- 1. Identify Political Boundaries of Populated Areas:** Plot populated entities (MSAs, PMSAs, counties, zip code areas, census tracts, or census blocks). Identify where the majority of the people live. Identify a grouping of populated entities that define a contiguous area and designate this as an initial MPA. According to the new regulations, MPAs are required to correspond to all metropolitan statistical areas with populations greater than 200,000. The regulations also state that the MSA boundaries do not necessarily have to correspond to the proposed MPA, and that air planning district boundaries may be used.
- 2. Identify Natural Air Basins:** Compare outer boundaries of the initial MPA on a topographic map showing terrain that might engender trapping, channeling, or separation of source emissions from populated areas. When terrain features are near the initial MPA boundary, add or subtract population entities to correspond as closely as possible to the terrain features. When terrain features are significant within the MPA boundary, identify potential Community Monitoring Zones (CMZ) that are separated by ridges, lakes, or valleys, or that are bounded on one edge by a seacoast.
- 3. Locate Existing Air Quality Monitoring Sites:** Plot the locations of existing PM monitoring sites from NAMS, SLAMS, PAMS, IMPROVE, and special monitoring networks. Examine the extent to which these correspond to populated areas. Identify large distances between existing sites, and identify sites that appear to represent the same sizes of populated areas. Evaluate the justification for excluding existing sites outside of the initial MPA boundaries. If these are community oriented sites, extend the initial MPA boundaries with populated

entities to include these sites. Alternatively, evaluate these sites for potential as special monitoring, transport or background sites. If existing sites outside of the MPA do not qualify as any of these, designate these for potential discontinuation in favor of sites that better attain one of the monitoring objectives.

4. **Reconcile Boundaries with Existing Planning Areas:** Plot boundaries of existing planning areas, such as air quality management districts, urban master plan boundaries, and/or transportation planning regions. Make initial MPA boundaries correspond to existing planning boundaries. Add or subtract populated entities to define the MPA as closely as possible to the existing boundary. Where major adjustments are needed to accommodate existing planning boundaries, define initial CMZs or general areas for locating core sites within those boundaries according to the procedure in Section 4.

3.1 Identify Political Boundaries of Populated Areas

Appendix B lists Metropolitan Statistical Areas (MSA) and Primary Metropolitan Statistical Areas (PMSA) in the United States. Figures 3.1.1 and 3.1.2 show these statistical areas for the continental U.S. with shading for their populations in 1990 and 1995, respectively. The 1990 census values are to be used to determine population cut-offs, and in most cases these do not differ by more than $\pm 10\%$ from the 1995 estimates. Tables 3.1.1 and 3.1.2 are extracts from Appendix B for the states of Alabama and California, respectively. The MSAs and PMSAs are named after the most populated cities or counties and are intended to include the economic influence of a population center. Their boundaries may correspond to county or municipal borders.

In Alabama, the MSAs range from $\sim 1,500 \text{ km}^2$ to $8,000 \text{ km}^2$, with population densities of ~ 40 to 100 people/km^2 . This is typical of many eastern states, where the counties are relatively small compared to those of the west. In California, on the other hand, the MSAs range from $\sim 1,000 \text{ km}^2$ to $>20,000 \text{ km}^2$, with 1990 population densities from 25 people/km^2 to $>1,100 \text{ people/km}^2$. The most extreme cases in Appendix B are: 1) the Las Vegas MSA that covers more than $100,000 \text{ km}^2$ and includes Nye, Clark, and Mohave Counties, among the largest counties in the U.S.; and 2) the Jersey City PMSA that includes only 120 km^2 of Hudson County with one of the highest U.S. population densities ($>4,500 \text{ people/km}^2$). More than 95% of the population in the Las Vegas MSA lives in the southern portion of Clark County, occupying less than 5% of the MSA land area, while the Jersey City PMSA has high population density throughout. While the majority of the MSAs remained in the same categories from 1990 to 1995, there are several that exceeded 200,000 in population by the year 1995. The Las Vegas MSA continued to grow and changed from a $>500,000$ category to a >1 million category by 1995.

Countywide population maps and MSA designations are most useful for identifying those parts of a state that are not required to perform community exposure monitoring. MSAs are not useful for defining the boundaries of MPAs in most cases. Figure 3.1.1 and Appendix B show a wide variation in populations among the MSAs. A large number of these had less than 500,000 people in them during 1990, and these are mostly in the non-coastal western states. There are many small but highly populated MSAs along the east

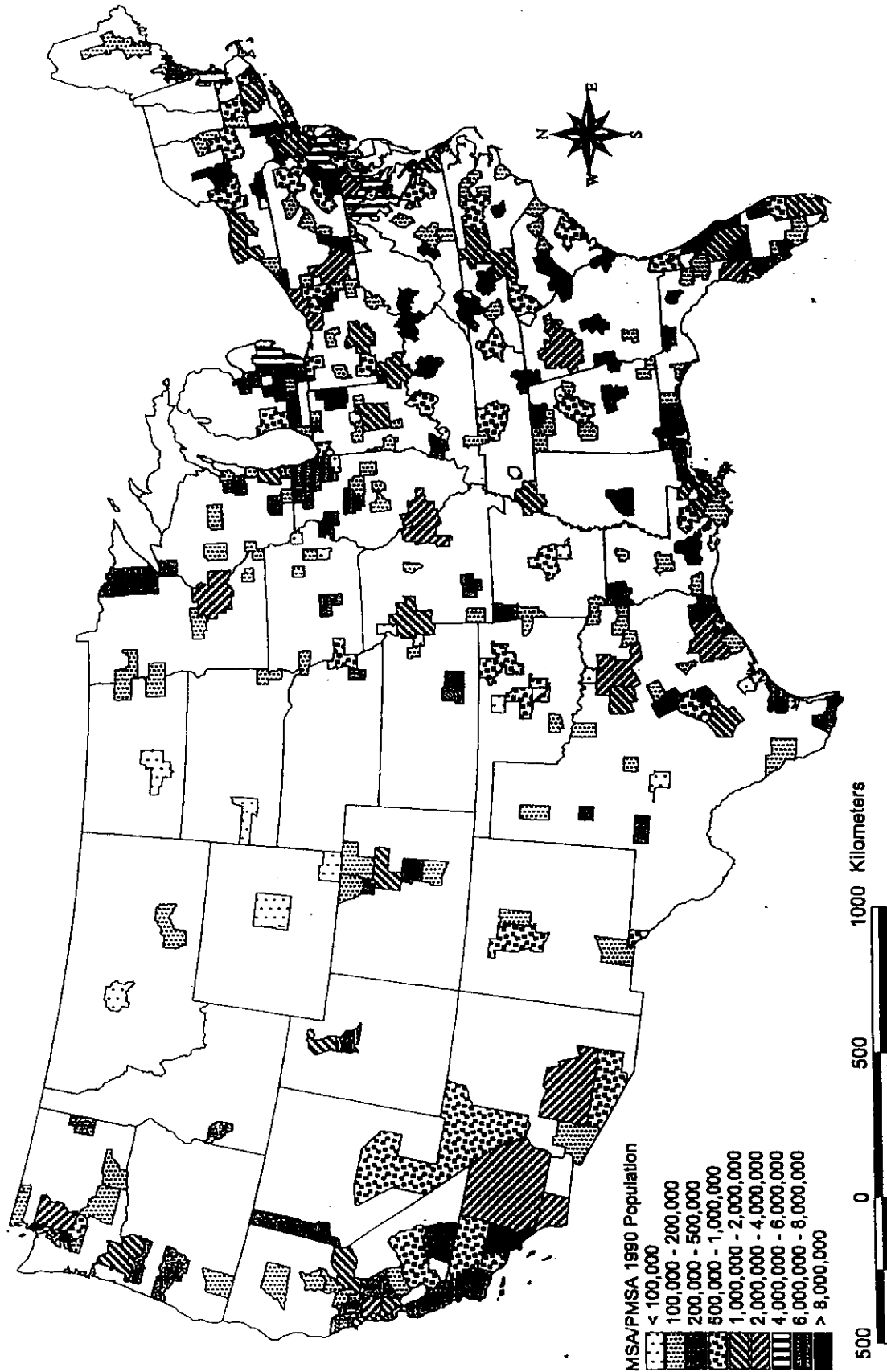


Figure 3.1.1. Metropolitan Statistical Areas and Primary Metropolitan Statistical Areas in the continental U.S. with 1990 populations.

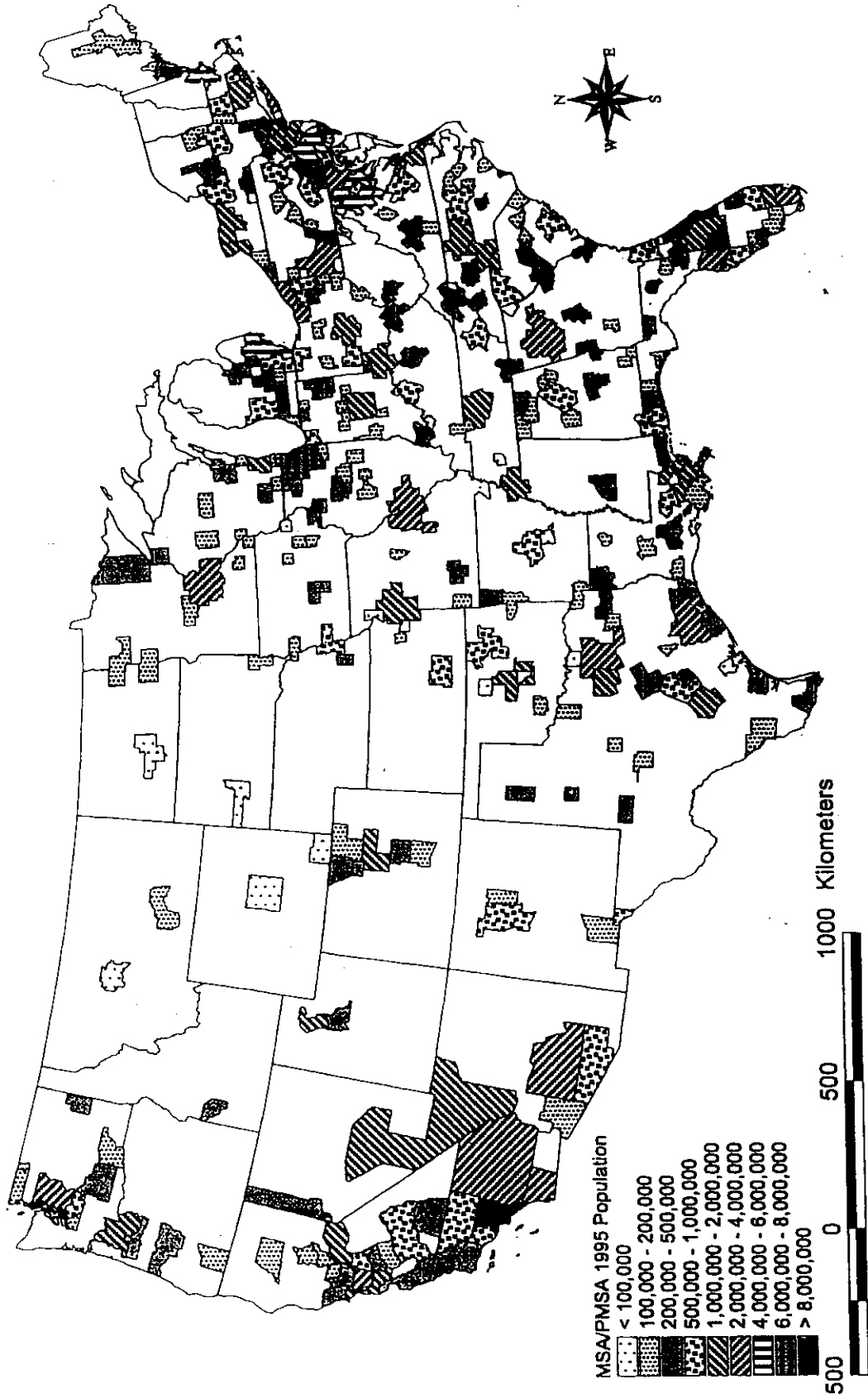


Figure 3.1.2. Metropolitan Statistical Areas and Primary Metropolitan Statistical Areas in the continental U.S. with 1995 populations.

State	Metropolitan Area	TYPE	Counties	1990 Population	1995 Est. Population	1995 pop density (km ²)	Area (km ²)
AL	Anniston, AL	MSA	Calhoun County	116,034	117,263	74.4	1576.0
AL	Birmingham, AL	MSA	Blount County Jefferson County St. Clair County Shelby County	840,140	881,761	106.8	8,255.0
AL	Decatur, AL	MSA	Lawrence County	131,556	139,837	42.3	3304.0
AL	Dothan, AL	MSA	Morgan County	130,964	134,368	45.4	2956.6
AL	Florence, AL	MSA	Houston County	131,327	136,184	41.6	3274.0
AL	Gadsden, AL	MSA	Colbert County	99,840	100,259	72.4	1385.2
AL	Huntsville, AL	MSA	Lauderdale County	293,047	317,684	89.3	3556.2
AL	Mobile, AL	MSA	Etowah County Limestone County Madison County	476,923	517,611	70.6	7329.4
AL	Montgomery, AL	MSA	Baldwin County Mobile County	292,517	315,332	60.6	5199.3
AL	Tuscaloosa, AL	MSA	Autauga County Elmore County Montgomery County Tuscaloosa County	150,522	158,732	46.2	3432.4

Table 3.1.1. Alabama Metropolitan Statistical Areas and Primary Metropolitan Statistical Areas.

State	Metropolitan Area	TYPE	Counties	1990 Population	1995 Est. Population	1995 pop density (km ⁻²)	Area (km ²)
CA	Bakersfield, CA	MSA	Kern County	543,477	617,528	29.3	21086.7
CA	Chico-Paradise, CA	MSA	Butte County	182,120	192,880	45.4	4246.6
CA	Fresno, CA	MSA	Fresno County Madera County	755,580	844,293	40.2	20983.3
CA	Los Angeles-Long Beach, CA	PMSA	Los Angeles County	8,863,164	9,138,789	869.1	10515.3
CA	Los Angeles-Riverside-Orange County, CA	CMSA	Los Angeles County Orange County Riverside County San Bernardino County Ventura County	14,531,529	15,362,165	174.4	88080.4
CA	Orange County, CA	PMSA	Orange County	2,410,556	2,563,971	1253.6	2045.3
CA	Riverside-San Bernardino, CA	PMSA	Riverside County San Bernardino County	2,588,793	2,949,387	41.8	70629.2
CA	Ventura, CA	PMSA	Ventura County	669,016	710,018	148.5	4781.0
CA	Merced, CA	MSA	Merced County	178,403	194,407	38.9	4995.8
CA	Modesto, CA	MSA	Stanislaus County	370,522	410,870	106.1	3870.9
CA	Redding, CA	MSA	Shasta County	147,036	160,940	16.4	9804.8
CA	Sacramento, CA	PMSA	El Dorado County Placer County Sacramento County	1,340,010	1,456,955	137.8	10571.3
CA	Yolo, CA	PMSA	Sacramento County	141,092	147,769	56.4	2622.2
CA	Salinas, CA	MSA	Monterey County	355,660	348,841	40.5	8603.8
CA	San Diego, CA	MSA	San Diego County	2,498,016	2,644,132	242.8	10889.6
CA	Oakland, CA	PMSA	Alameda County Contra Costa County	2,082,914	2,195,411	581.5	3775.7
CA	Sacramento-Yolo, CA	CMSA	El Dorado County Placer County Sacramento County Yolo County	1,481,220	1,604,724	121.1	13250.4

Table 3.1.2. California Metropolitan Statistical Areas and Primary Metropolitan Statistical Areas.

State	Metropolitan Area	TYPE	Counties	1990 Population	1995 Est. Population	1995 pop density (km ⁻²)	Area (km ²)
CA	San Francisco, CA	PMSA	Marin County San Francisco County San Mateo County	1,603,678	1,645,815	625.7	2630.4
CA	San Francisco-Oakland-San Jose, CA	CMSA	Alameda County Contra Costa County Marin County San Francisco County San Mateo County Santa Clara County Santa Cruz County Sonoma County Napa County Solano County	6,249,881	6,539,602	341.1	19173.7
CA	San Jose, CA	PMSA	Santa Clara County	1,497,577	1,565,253	468.0	3344.3
CA	Santa Cruz-Watsonville, CA	PMSA	Santa Cruz County	229,734	236,669	205.0	1154.6
CA	Santa Rosa, CA	PMSA	Sonoma County	388,222	414,569	101.6	4082.4
CA	Vallejo-Fairfield-Napa, CA	PMSA	Napa County Solano County	451,186	481,885	117.6	4097.5
CA	San Luis Obispo-Atascadero-Paso Robles, CA	MSA	San Luis Obispo County	217,162	226,071	26.4	8558.6
CA	Santa Barbara-Santa Maria-Lompoc, CA	MSA	Santa Barbara County	369,608	381,401	53.8	7092.6
CA	Stockton-Lodi, CA	MSA	San Joaquin County	480,628	523,969	144.6	3624.5
CA	Visalia-Tulare-Porterville, CA	MSA	Tulare County	311,921	346,843	27.8	12495.0
CA	Yuba City, CA	MSA	Sutter County Yuba County	122,643	136,104	42.6	3193.9

Table 3.1.2 (continued). California Metropolitan Statistical Areas and Primary Metropolitan Statistical Areas.

coast, in the upper midwest, and along the gulf coast. California dominates the west coast with the largest number of and most populated MSAs.

Figure 3.1.3 shows a continental U.S. map of federal lands that are generally low in population. While these are not of interest for community-oriented monitoring, many of them are good candidates for background monitoring sites. Currently operating stations from the IMPROVE network are plotted on this map, and these provide the first preference for background sites. While the western states have an abundance of these pristine areas, and a long history of IMPROVE background monitoring, the coverage in midwestern, eastern, and southern states is sparse.

Counties, zip code areas, census tracts, and census blocks have population attributes that qualify them as populated entities. These boundaries are available from the 1990 U.S. census that also contains 1990 and 1995/1996 population estimates associated with each entity. Population estimates and 1990 census data are available from the U.S. Census Bureau in electronic and paper formats. See Appendix A for sources of population data. Figure 3.1.4 shows these populated entities in the Birmingham, AL MSA. This MSA consists of four counties, but Blount and St. Clair counties in the upper right of the MSA have no principal cities and small populations. More than 80% of the people in the MSA live in Jefferson County, in and around the principal cities noted in Figure 3.1.4a. The largest and most central of these cities is Birmingham, the largest city in Alabama.

Figure 3.1.4b shows zip code boundaries in Jefferson and Shelby counties; these are more dense and of smaller size in and around the city of Birmingham. Five-digit zip codes may be associated with a few hundred people in rural areas, or with tens of thousands of people in urban areas. Figure 3.1.4c shows census tracts, each containing from 1,000 to 8,000 people, for both counties. These are very small, and often highly populated, in the urban area of south-central Jefferson County, but they become larger and less densely populated toward the north, east, and west edges of the county. Finally, Figure 3.1.4d shows the boundaries for census blocks. Census blocks are subsets of the census tracts, and may contain from 500 to 5,000 people. Their small sizes in the populated area, and their comparable sizes to the census tracts in the less populated periphery of Jefferson County, makes census blocks less desirable than census tracts for defining MPAs, CMZs or general areas for community-oriented monitoring in this MSA.

From these figures, it appears that census blocks provide more population detail than is needed for defining an MPA. Zip code boundaries provide reasonable distributions except at the edges of a potential MPA. Census tracts are probably the most practical units of population to define political boundaries for the Birmingham MPA. In Birmingham, AL, the Jefferson County boundaries provide the first estimate of the MPA, with some of northern parts of Shelby County that abut the Birmingham metropolitan area. As will be seen below, county boundaries are not good starting points for California's San Joaquin Valley.

3.2 Identify Natural Air Basins

In many states, including Alabama and California, political boundaries do not necessarily correspond to terrain features that may trap or channel source emissions or

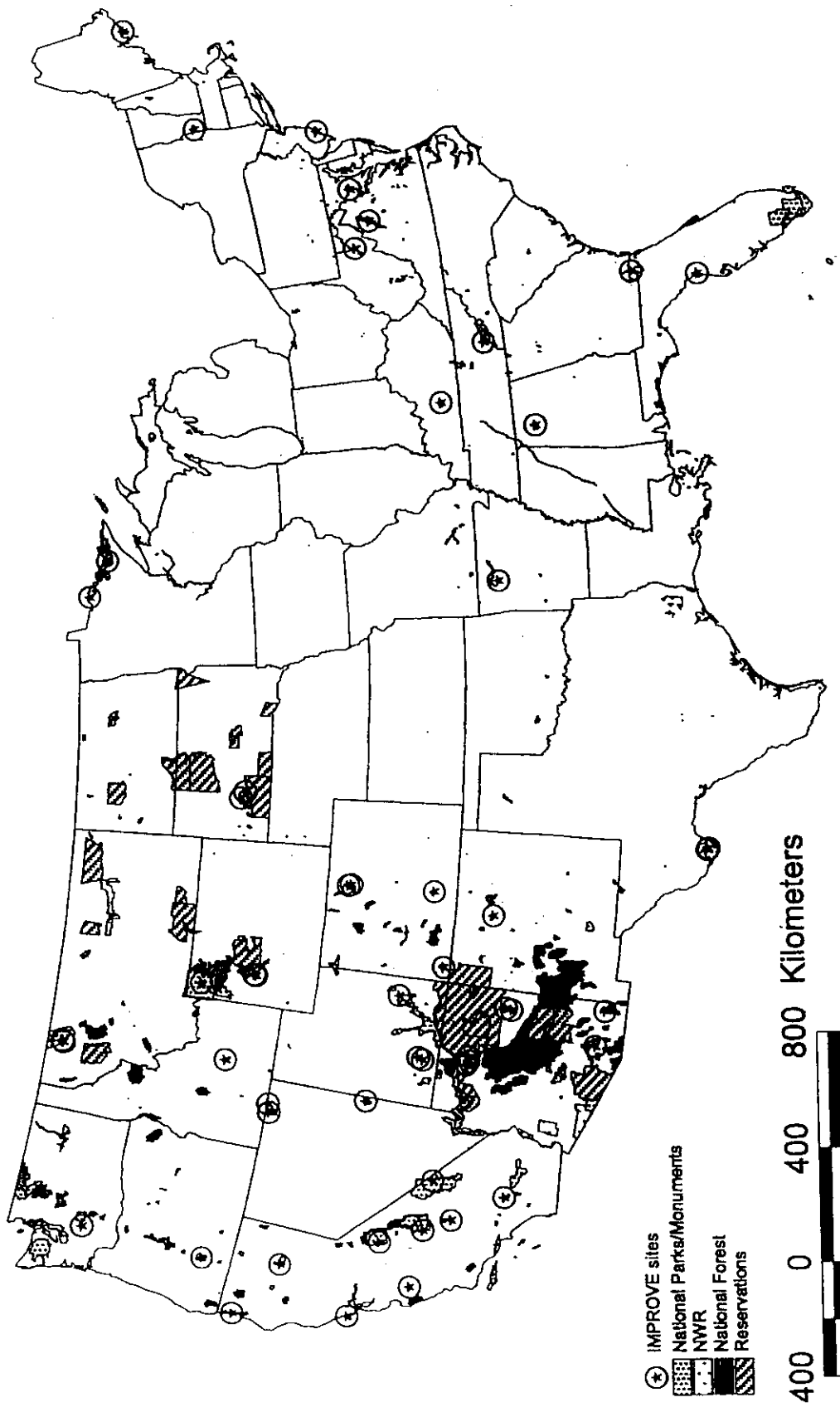
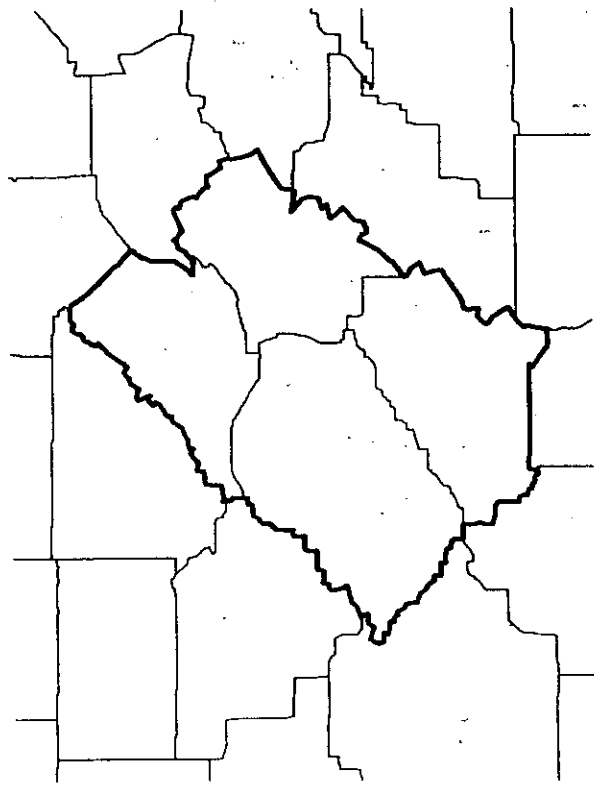
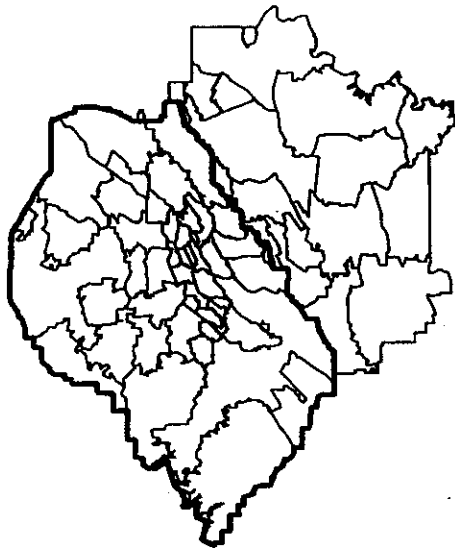


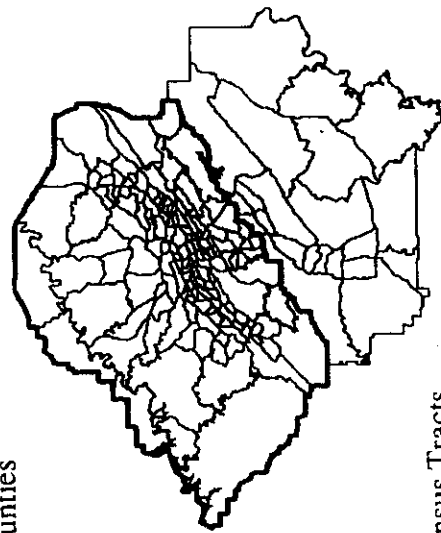
Figure 3.1.3. National parks and monuments, national wildlife refuges, national forests, Indian reservations, and IMPROVE background monitoring sites.



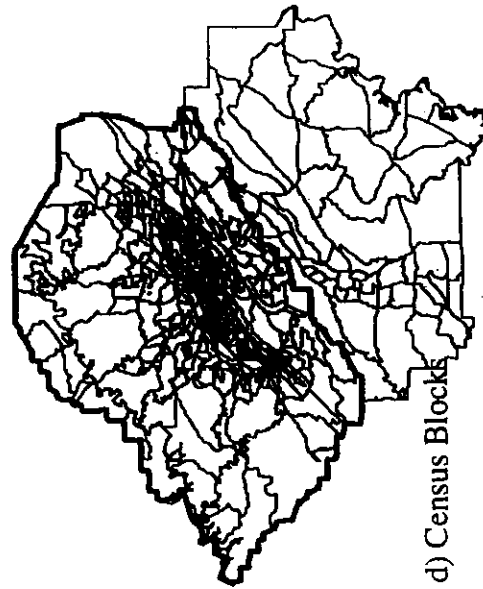
a) Counties



b) Zip Codes



c) Census Tracts



d) Census Blocks

Figure 3.1.4. Populated entities in the Birmingham MSA: a) counties, b) zip codes, c) census tracts, and d) census blocks.

separate emissions from populations. These terrain features may be larger than the single populated area that represents an MPA, or there may be several terrain features that affect concentrations within an MPA. USGS maps with scales of 1:250000, 1:50000 and 1:24000 are useful defining these boundaries. Smaller scale (1:250,000) maps are readily available in electronic format. See Appendix A for sources. This scale is marginally adequate for identifying Monitoring Planning Areas.

Figure 3.2.1 shows the Birmingham MSA in relation to the terrain of the state of Alabama. Alabama is relatively flat toward the south, with the southwestern end of the Appalachian mountain range penetrating into its northeast corner as far as Jefferson County. Birmingham and its neighboring cities are situated along the narrow valleys that constitute the end of this range. These northwest to southeast valleys are separated by ridges that barely attain 300 m in height above the valley floors, and people live and work both within the valleys, on the hillsides, and on the ridges. The populated entities in Figure 3.1.3 can be seen to follow this terrain, as do the major transportation corridors.

The Opossum Valley, just to the north of downtown Birmingham, contains a large industrial complex that extends nearly 40 km to the northeast and southwest from the most densely populated entities. These industries are interspersed with residences in the Opossum Valley, and lie just north of low ridges that separate Opossum from the valleys to the south. The hills are low enough that they probably do not channel local flows, except possibly during night or morning when temperature inversions might induce shallow mixed layers. Table 3.1.1 shows few other highly populated areas in Alabama. Mobile, AL, is on the gulf coast and it is unlikely to have a major influence on pollution in Birmingham. Huntsville to the north and Montgomery to the south have ~300,000 people in their MSAs and little heavy industry. Much of the area between cities is forested or occupied by small farms. Precipitation is abundant, and there is little bare land within the state. The Birmingham MSA may be affected by a superposition of contributions from regional-scale emitters in the southeastern U.S. and urban-scale and neighborhood-scale sources within the MPA.

The San Joaquin Valley (SJV) in central California, shown in Figure 3.2.2, is a significant contrast to Birmingham, AL. This is a complex region, from an air quality and meteorological perspective, owing to its proximity to the Pacific Ocean, its surrounding terrain that affects air flows, its diversity of climates, and its large population centers separated by vast areas of intensively cultivated farmland. Central California contains nearly half of the state's 32 million people.

The SJV encompasses nearly 64,000 square kilometers and contains a population in excess of 3 million people. The majority of this population is centered in the large urban areas of Bakersfield, Fresno, Modesto, and Stockton, though there are nearly 100 smaller communities in the region. The San Francisco Bay area, with more than 6 million people, and a much higher population density than that of the SJV, is generally upwind during non-winter months.

The SJV is bordered on the west by the Coast Mountain range, rising to 1,530 meters (m) above sea level (ASL), and on the east by the Sierra Nevada range with peaks exceeding 4,300 m ASL. These ranges converge at the Tehachapi Mountains in the southernmost end

of the valley with mountain passes to the Los Angeles basin (Tejon Pass, 1,256 m ASL) and to the Mojave Desert (Tehachapi Pass, 1,225 m ASL). These are significant orographic

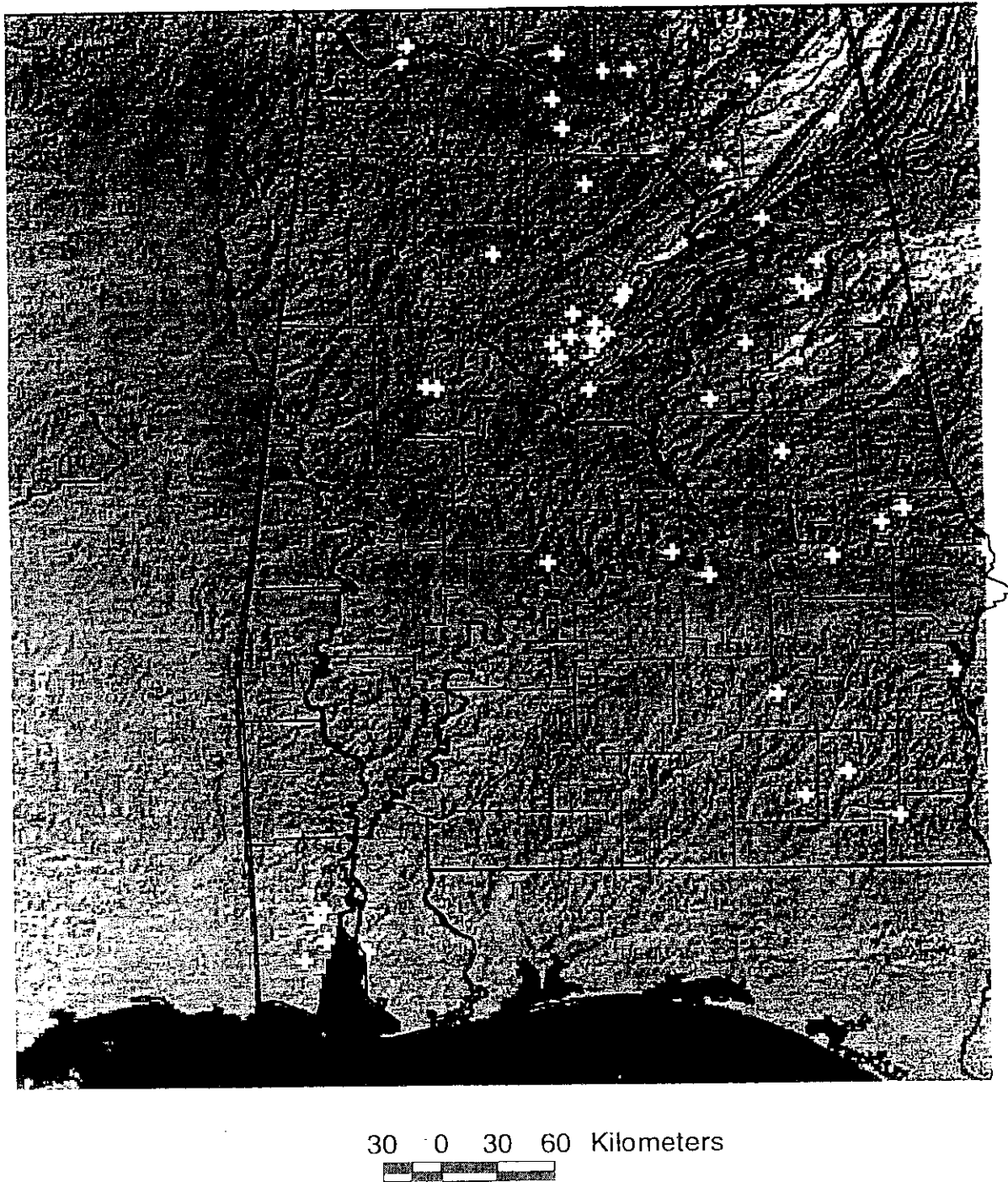
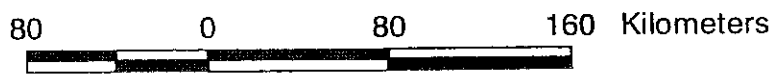
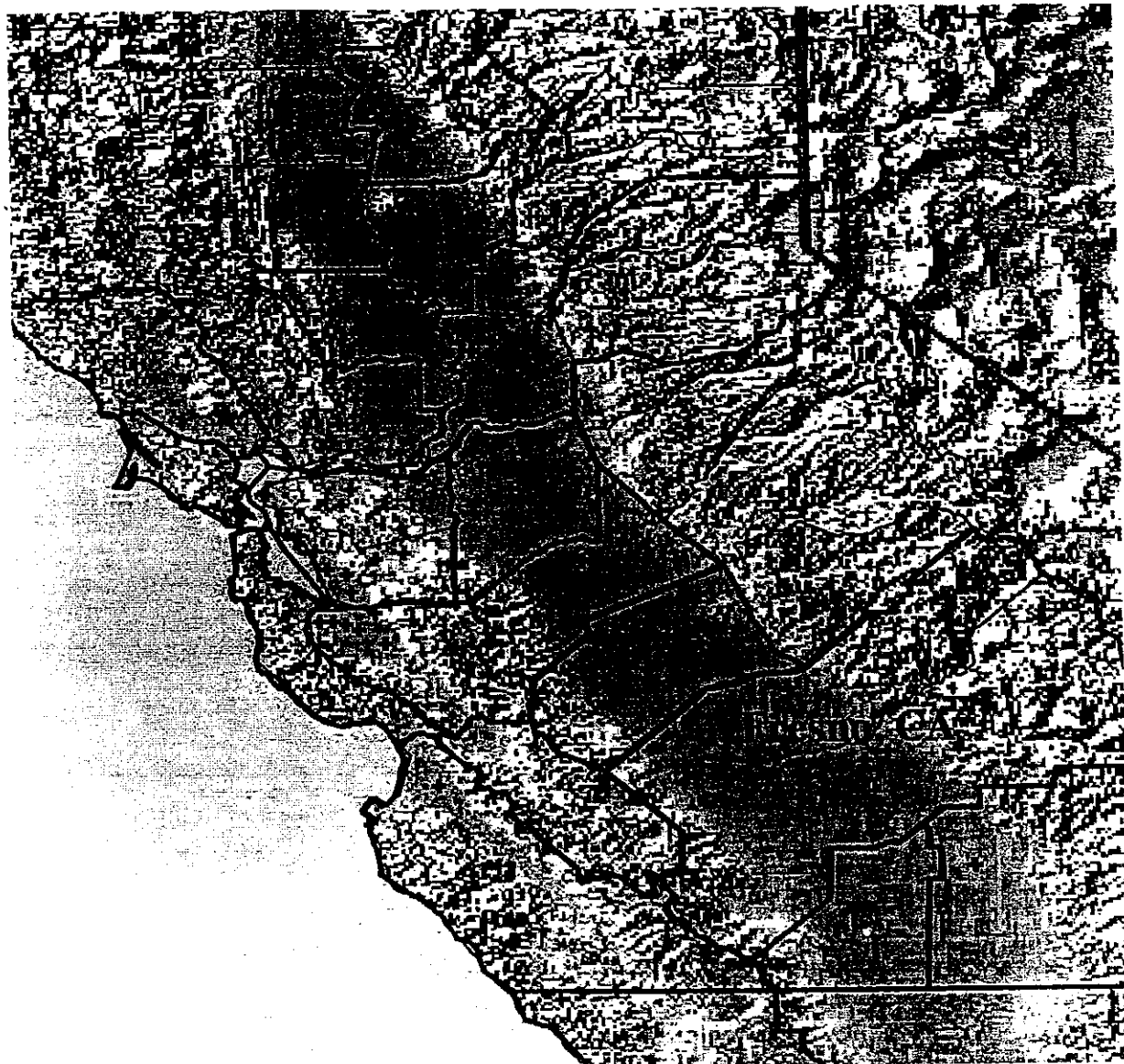





Figure 3.2.1. The Birmingham MSA in relation to counties, principal cities (+), and terrain in Alabama.



-  county
-  cities
-  MSA boundaries

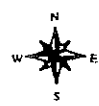


Figure 3.2.2. Central California MSAs in relation to counties, principal cities (+), and terrain.

barriers that can channel flow. There is little heavy industry in the SJV. Agriculture of all types is the major industry, with oil and gas production and refining, waste incineration, electrical co-generation, transportation, commerce, and light manufacturing constituting the remainder of the economy. The climate is arid, with precipitation only in the winter. Bare land is prevalent throughout the region, especially after harvests and prior to re-planting. There is much potential for transport between populated areas within the SJV, from outside of the SJV into the Valley, and from the rural areas to the populated areas.

The populated entities in the SJV are large and extend into the coastal mountains and the Sierra Nevadas. The most populated areas are on the flat terrain between the two ranges, and these are in a line following SR 99 on the eastern side of the Valley.

3.3 Identify Existing Air Quality Monitoring Sites

Figure 3.3.1 shows particle monitoring sites that are currently operated, or were operated in the past, by the Jefferson County Department of Health. Some of these have been discontinued, but their data should still be evaluated along with the cause for their termination. The Jefferson County network corresponds well to the populated entities. Sites are located both within the Opossum Valley, as well as in the southern valleys. The measurements at the Inglenook site, which is furthest north, and the Leeds Elementary School site, which is furthest east, are in areas with lower population, and they might be evaluated as potential background or transport locations, or as monitors in a separate CMZ.

Figure 3.3.2 shows census tracts with past and current PM monitoring sites in the San Joaquin Valley. The areas with the densest concentrations of tracts have one to three monitors apiece. There are also several monitoring sites along the southwestern side of the Valley, in the Sierra Nevadas to the east, and in the Mojave Desert (eastern Kern County). Several of these sites may be appropriate as source-oriented SPMs, background sites, or transport sites.

Figures 3.3.3 and 3.3.4 show potential MPAs determined by census tracts for Jefferson County and the San Joaquin Valley, respectively. Notice that the MPA for Jefferson County also includes a few of the more densely populated tracts in Shelby County, as this appears to be an area of growth in residential housing. Notice that three separate MPAs are identified for the San Joaquin Valley, each corresponding to the most highly populated portions of an MSA and including existing community-oriented monitoring sites.

3.4 Reconcile Boundaries with Existing Planning Areas

Population entities can be added or subtracted at the edges of initial MPAs to correspond to existing boundaries, but the MPAs should still correspond to populated areas. Air pollution control agencies such as the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) are responsible for large geographic areas, several MSAs and several initial MPAs. These areas have two options for reconciling the MPAs with their boundaries:

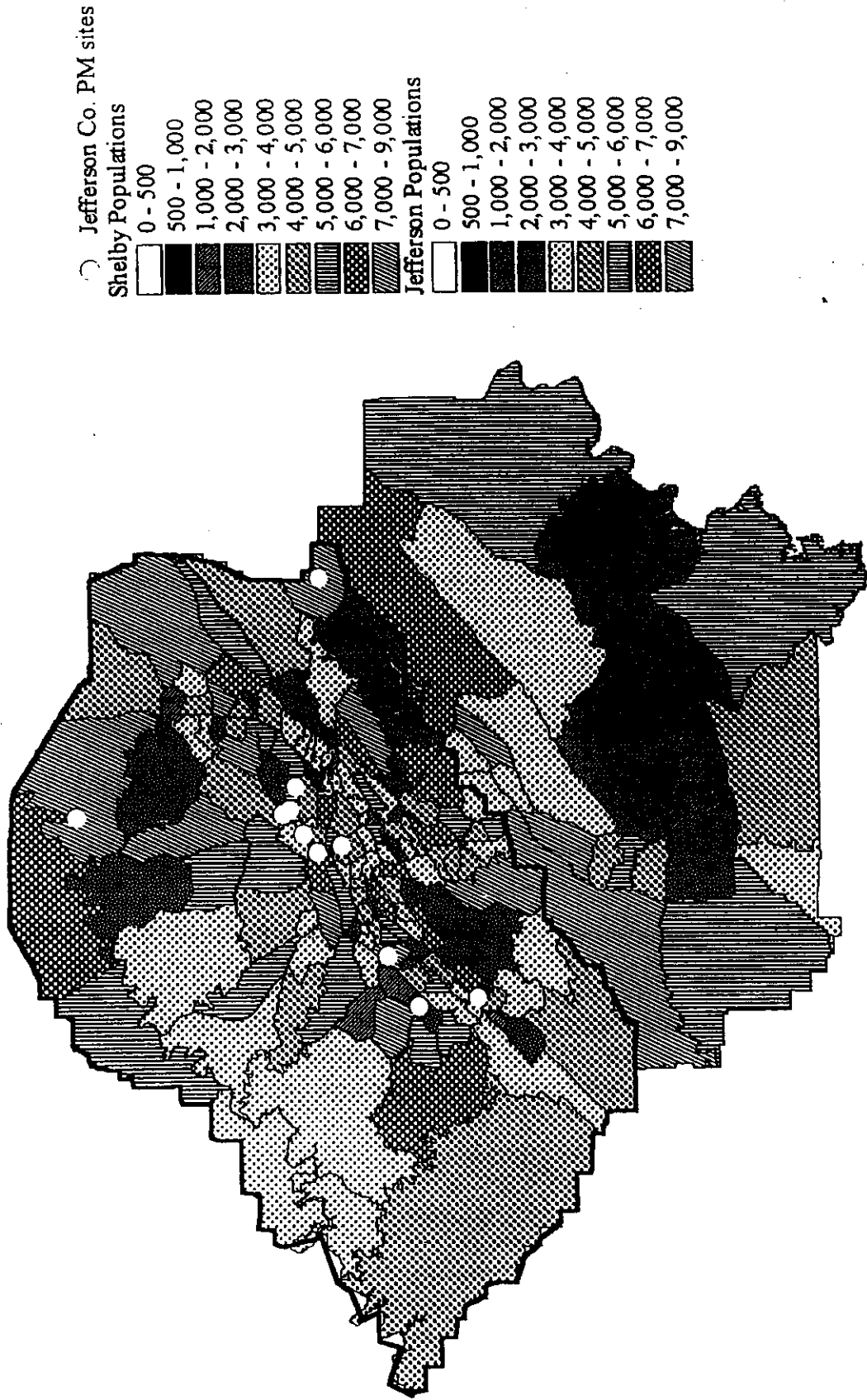


Figure 3.3.1. Populations in Jefferson and Shelby county census tracts. Jefferson County Health Department PM monitoring sites are shown.

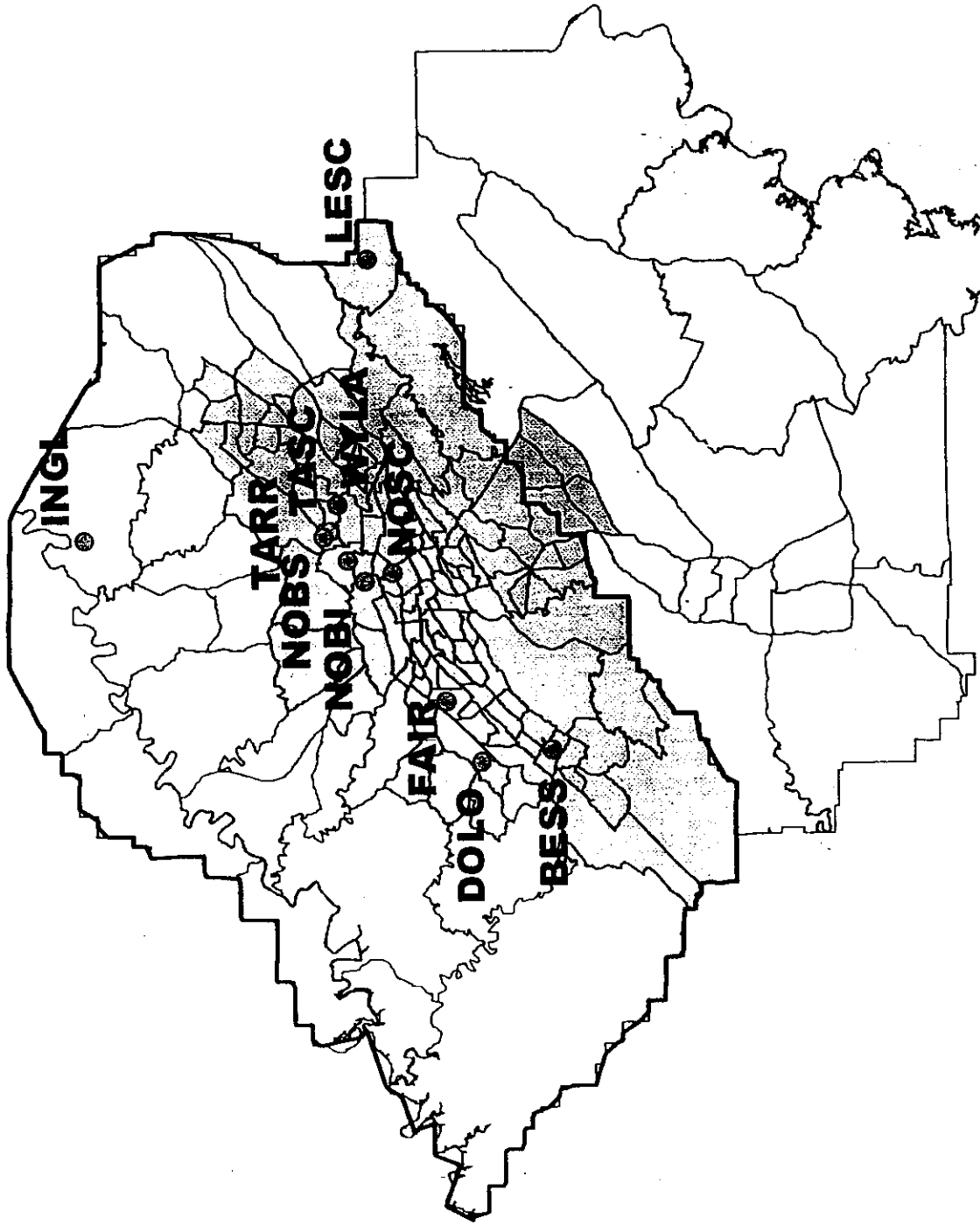


Figure 3.3.2. Potential Monitoring Planning Area for the Birmingham MSA. Dots represent monitoring sites.

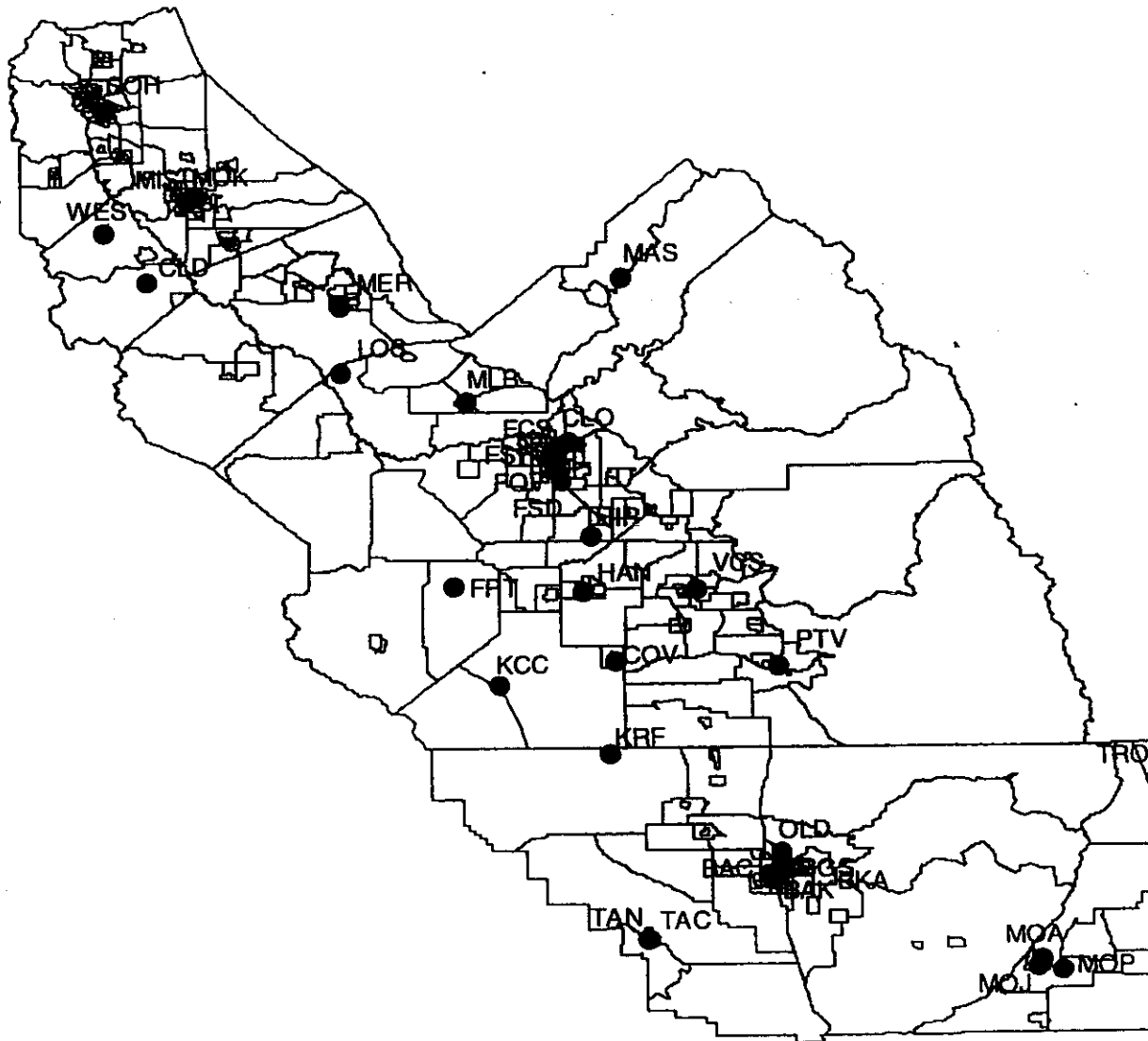
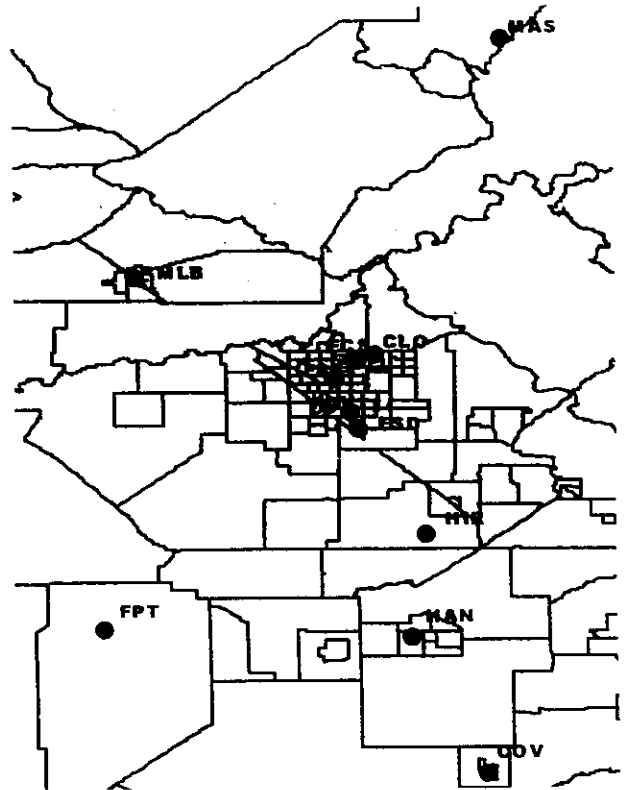
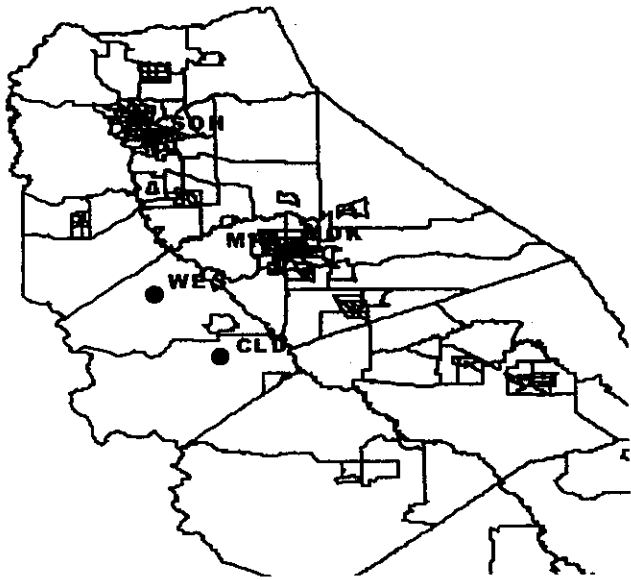
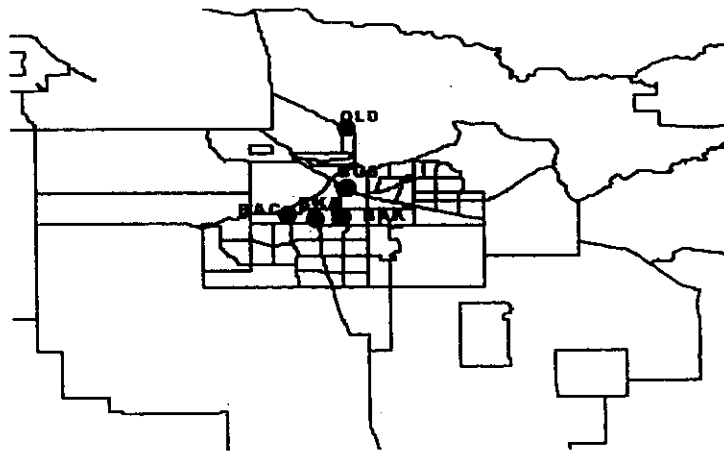


Figure 3.3.3. Census tract boundaries and past and present PM monitoring sites in California's San Joaquin Valley.



a) Stockton/Modesto

b) Fresno/Madera/Clovis/Selma



c) Bakersfield

Figure 3.3.4. Potential San Joaquin Valley MPAs: a) Stockton/Modesto, b) Fresno/Madera/Clovis/Selma, and c) Bakersfield.

- Several MPAs can be designated within the existing jurisdiction, as shown in Figure 3.3.4. Areas between or along the edges of these MPAs become target areas for transport and background monitors, or as SPMs if they are intended to determine specific source influences.
- The MPA can be defined as identical to the existing jurisdictional boundaries. The initial MPAs, such as those in Figure 3.3.4, can be designated as one or more CMZ within the MPA.

In the first option, compliance is determined from SLAMS and other compliance sites within the MPA portions of the jurisdiction, where the most people are exposed to PM_{2.5}. Special purpose monitoring between and around these MPAs may be used for source assessment, and may result in emission reduction requirements outside of the MPAs. Alternatively, special purpose transport monitors between the MPAs might be appropriate. In both instances, the data from these SPMs are not necessarily needed for compliance assessments. In the second option, all areas within the jurisdiction are part of an MPA, and measurements from any part may be used for determining compliance.

In other cases, the MPA may extend outside of the current boundaries of the air quality control agency, as for the Birmingham metropolitan area that extends south into Shelby County, AL. There are two options in this case:

- Designate two adjacent MPAs, with the dividing line at jurisdictional lines. This has the advantage of making a clean break between the two administrative agencies, but the disadvantage of complicated coordinated emissions reduction strategies should the PM_{2.5} standards be exceeded.
- Designate one MPA, but with separate CMZs (or core monitoring sites) divided by the jurisdictional line. This has the advantage of allowing monitoring networks to be administered by the existing air pollution control agencies, while allowing for more coordinated planning with respect to needed emissions reductions should the standards be exceeded within different jurisdictions.

The Jefferson County Department of Health has jurisdiction over all air quality monitoring in the county, but none in Shelby County. Shelby County conducts no PM monitoring, and it does not maintain an infrastructure for air quality monitoring and emissions control. These functions are handled by the state for most of the lightly populated counties in Alabama. In this case, the few northern Shelby tracts in Figure 3.3.2 might be eliminated from the MPA to keep the MPA entirely within the jurisdiction of Jefferson County. It is possible that measurements entirely within Jefferson County adequately represent population exposures just south of the Jefferson County border. This hypothesis could be tested by short-term SPMs in Shelby County.

3.5 Summary

Figures 3.3.3 and 3.3.4 show potential MPAs for Birmingham, AL, and for portions of California's San Joaquin Valley that can be used as examples for other areas. In the Birmingham case, the potential MPA is smaller than the entire county and corresponds to the ~100 km long by ~20 km wide swath that cuts through Jefferson County, and extends partially into Shelby County to the south. It corresponds on its edges to terrain features, but it also includes several valleys.

In the San Joaquin Valley portion of Central California, three MPAs are defined within the existing boundaries of the SJVUAPCD for Stockton/Modesto, Fresno/Madera/Clovis/Selma, and Bakersfield, the most highly populated regions of the Valley. The detailed population maps of these areas show that there is substantial difference in population density within the Valley, and even within the proposed MPAs.

4.0 DEFINING PM_{2.5} COMMUNITY MONITORING ZONES

Community-oriented monitors and optional Community Monitoring Zones (CMZ) within MPAs are intended to quantify neighborhood-scale exposures that are added to underlying urban and regional PM contributions. In this discussion, the term CMZ is used to represent the specifically defined area required by the regulations when spatial averaging is intended for making comparisons to the annual PM_{2.5} NAAQS or a more general area only used for description of the communities represented by one or more core sites. CMZs are defined based on terrain, sources, and prior monitoring within and upwind of an MPA. Core sites and optional CMZs should be reviewed annually to determine whether or not additional core sites or CMZs are needed or changes to CMZ boundaries are appropriate. General locations for core sites and CMZs are defined by the following steps:

- 1. Locate Emissions Sources and Population:** Plot major land use within the populated entities within the categories of commercial, residential, industrial, or agricultural and the major roadways. Plot emissions from major point sources for primary PM, sulfur dioxide, and oxides of nitrogen. Use a gridded emissions inventory or maps of source type and density, if available. Each monitoring site in the CMZ will principally be affected by similar emission sources. Determine which populated areas coincide with or are in close proximity to areas of high source density and which are in areas of low source density. When evaluating community exposures to emissions, consider populations at work and leisure activities, as well as at home. Population density is important both for determining exposure and for estimating emissions from vehicles, cooking, woodburning, etc. Modify initial CMZ boundaries identified when defining MPAs to better represent exposure to nearby source emissions from commercial, residential, industrial, and agricultural emissions.
- 2. Identify Meteorological Patterns:** Plot wind directions and speeds, vertical temperature structure, and frequencies of fogs by season. Determine how these vary within and around the initial MPA and CMZs. Extend the dimensions of CMZs that include large source emissions in the downwind direction, using terrain as a guide for potential channeling.
- 3. Compare PM concentrations:** Determine the spatial homogeneity of average and maximum concentrations from previous measurements or model calculations within the potential CMZ for annual, seasonal, and maximum PM concentrations. Use measurements of PM_{2.5} or visibility if available; if not, use PM₁₀ or other air pollutant measurements. Combine potential CMZs where these concentrations are similar. When existing PM_{2.5} measurements are available, the CMZ should be chosen such that the average concentrations at individual sites does not exceed the spatial average by more than ± 20 percent on a year-by-year basis. Lastly, the CMZ is defined such that each site is generally well correlated with other sites in the CMZ on a day-to-day basis ($r > 0.6$).

4. **Adjust CMZs to jurisdictional boundaries:** Where air quality management jurisdictional boundaries are within a natural CMZ, divide the CMZ along these lines so that a separate CMZ resides within each jurisdiction.
5. **Locate Sites:** Where existing sites are within each CMZ, give them first priority of PM_{2.5} monitoring when they meet the siting criteria in Section 5. Where CMZs do not contain existing sites, apply the criteria of Section 5 to select new sites.

4.1 Locate Emissions Sources

As noted in Section 3, Jefferson County is highly industrialized in the Opossum Valley, but contains less industry in the other, adjacent valleys. Several different types of heavy industries are located in various clusters in the Opossum Valley, so two potential CMZs might be defined for each end of the MPA in Figure 3.3.2. The commercial central city also indicates another source area, but it is so close to the Opossum Valley that emissions are very likely to mix over the low ridges separating them. A third CMZ might be considered for the downtown area.

In contrast, California's San Joaquin Valley has little heavy industry. While crude oil combustion in Kern County to the south was associated with elevated sulfate levels in the past, this fuel source has been replaced with natural gas that brings countywide sulfur dioxide emissions down to levels comparable with those of other parts of the Valley. The initial CMZs are set equal to the MPAs illustrated in Figure 3.3.4, since each consists of mostly urban source emissions such as road dust, vehicle exhaust, residential wood burning, and oxides of nitrogen and sulfur dioxide from gasoline and diesel fuel combustion.

The AIRS-AFS database is a useful source for locating local emissions sources. A downloaded AFS database is usable with a GIS. There may be special cases where the TRIS inventory may provide species information. The local transit authority may be consulted for data on diesel fuel usage and bus routing. State Department of Transportation data on heavy truck registration (especially short haul bulk haulers) can be consulted.

4.2 Identify Meteorological Patterns

Figures 4.2.1 and 4.2.2 show examples of wind transport directions and distances for different seasons and different times of the day for National Weather Service wind data from the Birmingham, AL, and Fresno, CA, airports. The vertical axes of these plots represent distance in the north/south direction while the horizontal axes represent distances in the east/west direction. The plotted points are the distances and directions that emitted particles or precursors would travel if they were transported by the measured surface winds.

In Figure 4.2.1, the denser concentration of points in the southwest corner of the morning and nighttime plots indicates some, but not dominant, channeling through the valleys. Transport sites should definitely be located to the northeast. The afternoon plots in all seasons show a greater frequency of large transport distances and no special preference for transport direction. Wind speeds and transport distances are lowest at night during the

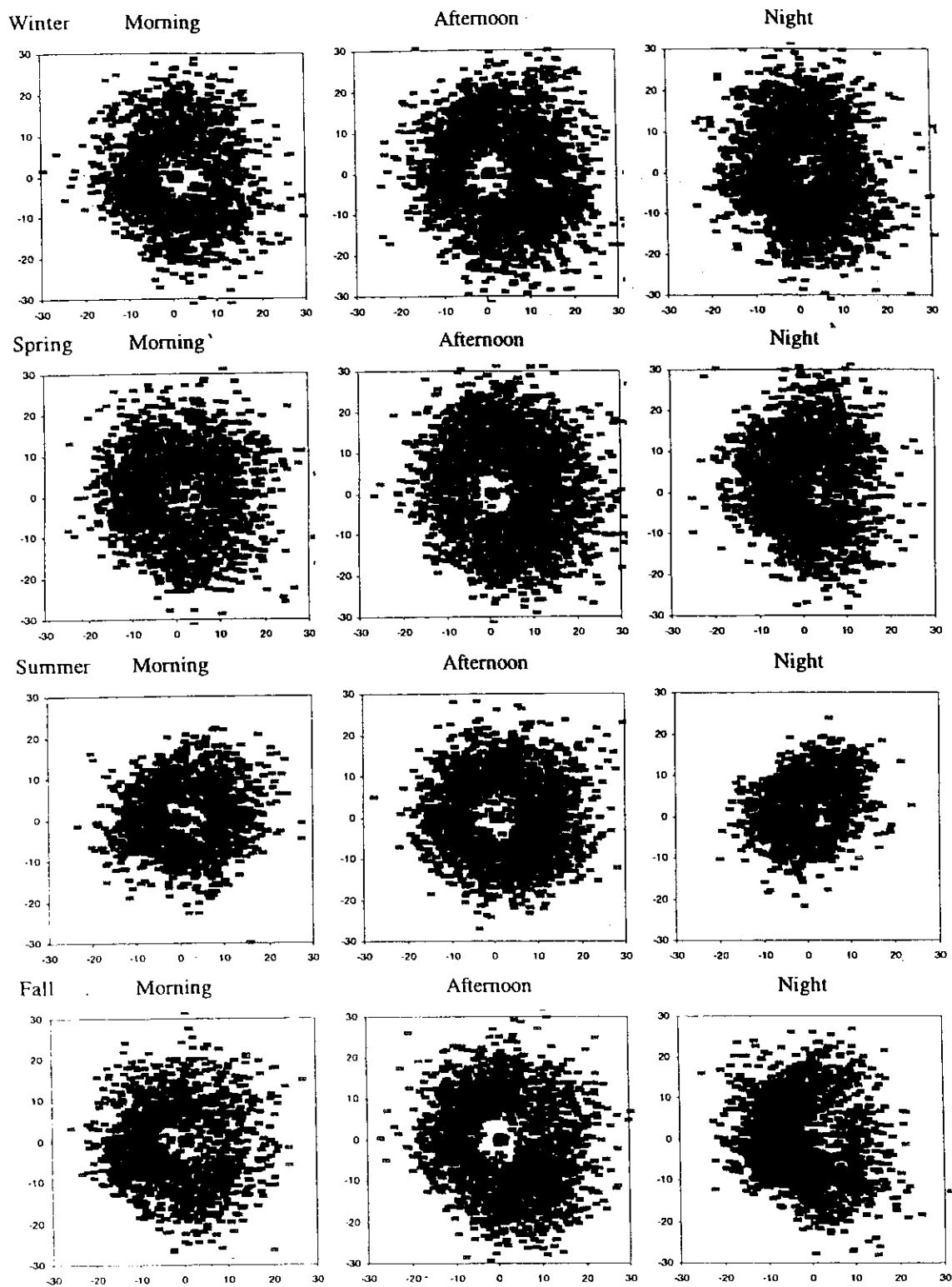


Figure 4.2.1. Hourly wind transport directions (from N) and distances (km). 1988-92 Birmingham airport winds for winter (Dec-Feb), spring (Mar-May), summer (Jun-Aug), and fall (Sep-Nov) during morning (0700-1000 CST), afternoon (1200-1600 CST), and night (2200-0500 CST).

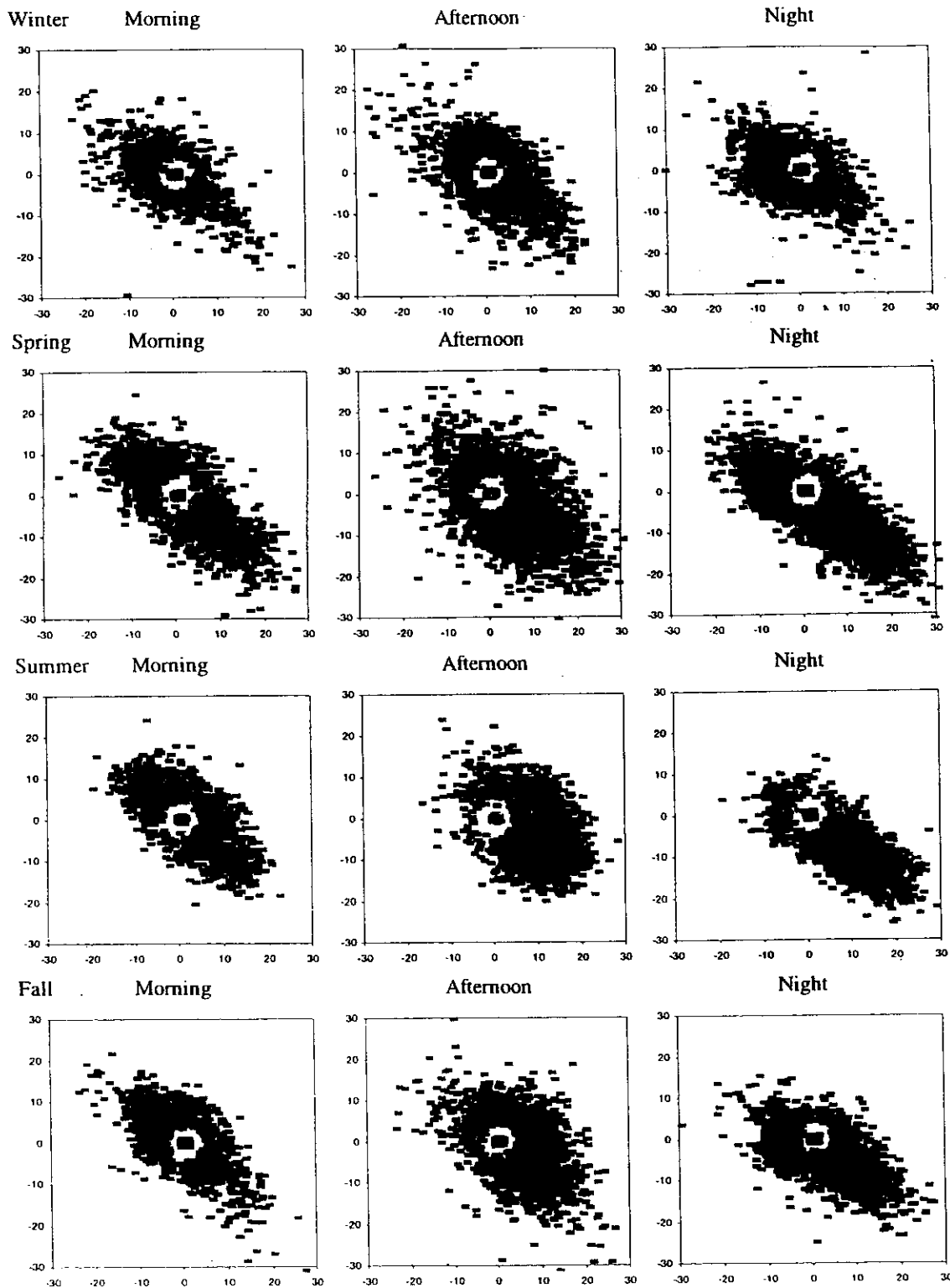


Figure 4.2.2. Hourly wind transport directions (from N) and distances (km). 1988-92 Fresno airport winds for winter (Dec-Feb), spring (Mar-May), summer (Jun-Aug), and fall (Sep-Nov) during morning (0700-1000 PST), afternoon (1200-1600 PST), and night (2200-0500 PST).

summer in Jefferson County. The implication of this brief meteorological analysis is that emissions can be transported in many directions, with a slight tendency toward the southwest. There is no reason to change the dimensions or orientations of the initial CMZs owing to transport.

Figure 4.2.2 from the San Joaquin Valley shows substantial channeling along the northwest to southeast axis of the Valley. The frequency and magnitude of transport is definitely from the northwest to the southeast, except possibly during winter when there are nearly equal densities of northwest and southeast transport.

These plots show that CMZs might be longer in the southeastern direction, downwind of source areas such as population centers, than in the northwestern direction.

Other useful displays of meteorological variables relevant to PM transport and formation are:

- **Annual and Seasonal Wind Roses:** Wind roses are compass-type plots of the frequencies of wind speeds and directions over a specified period. They are another method of representing the transport patterns shown in Figures 4.2.1 and 4.2.2. Wind roses show the dominant direction of near-surface transport. The directions often correspond to terrain-channeling in mountainous or hilly areas. These vary with season and time of day.
- **Time Series of Hourly Wind Directions and Speeds Corresponding to High Concentrations:** These plots show the magnitudes of hourly wind speeds and directions as a function of time throughout a day. Since there are many hourly wind measurements, these are only practical for selected 24-hour periods, usually those corresponding to high PM concentrations. Very low wind speeds with variable directions might correspond to a multi-day pollutant build-up in stagnant air. PM levels under these conditions are often dominated by neighborhood- and urban-scale emitters. Moderately high wind speeds that only correspond to a high PM level at one site may indicate contributions from a nearby upwind source. High wind speeds often dilute pollutant concentrations, but may engender suspension of fine particle fugitive dust. This dust may remain suspended for a long time and result in regional scale contributions.
- **Vertical Temperature Plots Corresponding to High Concentrations:** Where upper air soundings are available, temperatures as a function of height may be examined to estimate the depth of the mixed layer. During the winter, especially when snow is on the ground, intense temperature inversions may persist for several days in areas that are surrounded by elevated terrain. This allows the accumulation of urban and neighborhood scale emissions.
- **Frequencies of Fogs:** Plots of the number of hours during which fog is observed during the day, which are available from many National Weather Service summaries, indicate the potential for aqueous-phase conversion of sulfur dioxide

to sulfate. Reactions in fogs are the only mechanisms by which nearby sulfur dioxide emissions can transform into significant quantities of sulfate. Much of the sulfate observed in most locations without frequent fogs results from regional-scale transport during which slower non-aqueous reactions or reactions in elevated clouds occur.

4.3 Compare PM Concentrations

Few areas possess sufficient $PM_{2.5}$ measurements to permit comparisons for the first selection of CMZs. PM_{10} measurements are often available, and where these show acceptable spatial uniformity, it is likely that the $PM_{2.5}$ would also show homogeneity if it had been measured at the same locations. When the PM_{10} measurements are non-uniform among different sites, however, it may be the case that $PM_{2.5}$ concentrations are still spatially homogeneous, owing to the substantial differences in atmospheric residence times and zones of influence of emissions sources discussed in Section 2.

Several MPAs may have undergone an air quality modeling exercise to estimate PM_{10} and possibly $PM_{2.5}$ concentrations for a year or for high PM episodes. These modeled estimates can also be used in place of or in addition to measurements to further refine CMZs. As shown in Section 2, $PM_{2.5}$ is a complex combination of chemical compounds that is difficult to accurately represent in mathematical models. Emissions rates from area and mobile sources are often inaccurate, as these often are episodic and based on unknown fuels and operating conditions. Secondary particle formation depends on many factors that are often unknown. Transport under low-wind-speed conditions, that often accompany high PM levels, is not well measured or modeled. Modeling results need to be extensively evaluated against chemical- and size-specific $PM_{2.5}$ measurements to establish confidence that they accurately represent the applicable emissions, meteorological, and transformation processes. Once the validity of the modeling results has been established, $PM_{2.5}$ concentration isopleths can be compared with the initial CMZ boundaries to further improve the homogeneity of the CMZ.

Table 4.3.1 shows several uniformity measures from the seven PM_{10} measurement sites in Jefferson County: 1) Bessemer (BESS) in the southwest corner; 2) North Birmingham (NOBI) in the Opossum Valley ~0.5 km southwest of a steel-pipe forming plant; 3) Inglenook (INGL) in the northeast portion of the county; 4) Northside School (NOSC) in downtown Birmingham; 5) Leeds Elementary School (LESC) in the eastern-most corner of the county; 6) Wyland (WYLA) just northeast of Northside School; and 7) Tarrant Elementary School which is a few kilometers northeast of the North Birmingham site, but >1 km distant from a large industrial source complex. These seven sites, for which data are listed in EPA's AIRS data base, are fewer than the number of sites listed in the AIRS site log. Several source-oriented SPMs have been operated over several years in Jefferson County, and these data should be included in this type of analysis.

Annual Averages ($\mu\text{g}/\text{m}^3$)							
Year	BESS	NOBI	INGL	NOSC	LESC	WYLA	TASC
1990	33.5	47.6	34.6	40.3	30.7	38.1	37.3
1991	31.9	41.0	30.6	36.7	30.6	33.1	32.0
1992	28.4	38.6	28.5	31.2	27.7	31.4	30.1
1993	28.4	32.7	26.5	29.3	25.3	29.6	27.0
1994	24.8		24.7	27.2	23.7		25.6
1995	27.2			27.6	24.6		27.7

98th Percentile 24-Hour Averages ($\mu\text{g}/\text{m}^3$)							
Year	BESS	NOBI	INGL	NOSC	LESC	WYLA	TASC
1990	62	111	72	77	61	85	76
1991	79	100	75	80	70	78	76
1992	52	91	52	66	52	70	55
1993	58	81	62	69	61	64	58
1994	50		47	58	48		50
1995	56			52	50		57

Spatial Average Statistics ($\mu\text{g}/\text{m}^3$)									
Year	Spatial Average	Spatial Std	Spatial COV	Max Average	Min Average	Average +20%	Average -20%	Average +10%	Average -10%
1990	37.4	5.1	13.6	47.6	30.7	44.9	30.0	41.2	33.7
1991	33.7	3.5	10.5	41.0	30.6	40.4	26.9	37.0	30.3
1992	30.9	3.4	11.1	38.6	27.7	37.0	24.7	33.9	27.8
1993	28.4	2.2	7.9	32.7	25.3	34.1	22.7	31.2	25.6
1994	25.2	1.2	4.7	27.2	23.7	30.2	20.2	27.7	22.7
1995	26.8	1.2	4.7	27.7	24.6	32.1	21.4	29.4	24.1

Intersite PM_{10} Correlation Coefficients (1990-1993, n=226)							
	BESS	NOBI	INGL	NOSC	LESC	WYLA	TASC
BESS	1.000						
NOBI	0.848	1.000					
INGL	0.872	0.786	1.000				
NOSC	0.916	0.909	0.855	1.000			
LESC	0.873	0.809	0.885	0.856	1.000		
WYLA	0.811	0.879	0.822	0.834	0.846	1.000	
TASC	0.844	0.794	0.933	0.837	0.833	0.799	1.000

Table 4.3.1. Uniformity measures for PM_{10} in Birmingham.

The first two sub-sections of Table 4.3.1 show the annual arithmetic averages and 98th percentile (second highest 24-hour maximum with sixth-day sampling) for these sites. Note that the North Birmingham, Inglenook, and Wyland sites have no data after 1993. The North Birmingham hivol size-selective inlet (SSI) monitor was replaced by a continuous TEOM monitor that acquires hourly PM₁₀ concentrations daily, but this appears under a different AIRS code and was not extracted with this data set. There are known differences between TEOM and SSI PM monitors in areas with volatizable aerosol (Chow, 1995). Sudden changes in year-to-year concentrations might be due to changes in measurement method rather than as a result of emissions reductions. Only data from the same type of PM₁₀ samplers should be used in the analysis of prior data to select CMZs.

There are also changes in past data owing to emissions reductions. The Jefferson County data in Table 4.3.1 clearly shows the effects of stringent regulations on industrial emissions since 1990. The NOBI source-oriented site PM₁₀ concentrations were very different from the annual average and 98th percentile concentrations at other sites during 1990, but by 1993 they were much more similar to those at the other sites. In 1994, the INGL site in the northeast corner of Jefferson County, and the LESC site in eastern Jefferson County had similar average and 98th percentile PM₁₀ levels. In 1995, the BESS, NOSC, and TASC stations near the center of the MPA show almost identical annual averages, and 98th percentile PM₁₀ concentrations that differ by no more than 6 µg/m³. The LESC site shows ~3 µg/m³ lower annual PM₁₀ average, and a separate CMZ could be defined around this site. Alternatively, the MPA might be defined to be smaller than that represented in Section 3 for the Birmingham MSA, and the LESC site might be considered as a background or transport site.

The third segment of Table 4.3.1 shows how spatial averages of annual averages at the different Jefferson County sites vary from year to year. Notice that the spatial standard deviation decreased from 5.1 µg/m³ in 1990 to 1.2 µg/m³ in 1994. This resulted from the decrease in concentrations at the NOBI source-oriented site, and its elimination after 1993. Even in 1993, however, the spatial coefficient of variation (COV) was less than 10% when the NOBI site was included in the average.

The final panel of Table 4.3.1 shows the spatial correlation coefficients among the different sites for the 1990 through 1993 periods when data were available from each one. Each of these exceeds 0.8, with the exception of the NOBI site. This shows that the information content of the different monitoring locations is similar, and that some PM₁₀ sites can be sacrificed in favor of collocated PM_{2.5} sites at most of the Jefferson County sites.

Other analyses of historical PM₁₀ and PM_{2.5} that provide a basis for selecting CMZs, and also serve as a justification for de-commissioning PM₁₀ sites in favor of PM_{2.5} sites are:

- **Spatial Plots of Maximum, Annual and Seasonal Average PM:** These consist of pies or bars with areas or heights corresponding to PM concentration on a map. They can be displayed on the maps of source emissions in conjunction with the meteorological plots to gain a better understanding of source Zones of Influence and receptor Zones of Representation.

- **Time Series Plots of PM Mass and Selected Chemical Concentrations:** These consist of single or stacked bars of concentrations for each day. The chemical concentrations provide an indication of the types of regional, urban, or local sources that might be contributing.
- **Pollution Roses for Hourly PM Concentrations:** Pollution roses show the average concentration associated with a specific wind direction. These are only practical and useful when hourly data are available from an hourly PM monitor. Bias toward a specific direction may indicate an overwhelming influence from a nearby source. The sampling site may be judged as unrepresentative of the CMZ.

The CMZ boundaries are adjusted to include locations that show PM_{10} concentrations varying together. Sampling sites that show substantial deviations from other sites in the area are identified and reasons for their deviation is sought. These sites are excluded from consideration as core sites if they do not have neighborhood- or urban-scale zones of representation.

CMZ boundaries are adjusted to include contiguous groups of measurements that show a reasonable degree of spatial homogeneity, as indicated by the various homogeneity measures in the analyses above.

4.4 Adjust CMZs to Jurisdictional Boundaries

Just as the MPAs give preference to existing jurisdictional boundaries, the CMZ definitions may also conform to these boundaries as long as they consist of defined populated entities. These may include municipal borders or planning districts. An example has already been given in Section 3. A single MPA might include portions of Jefferson and Shelby Counties with two CMZs. The Jefferson County CMZ would be monitored by the Jefferson County Health Department. The Shelby County CMZ would be monitored by the State of Alabama. On the other hand, a special monitoring study might show that measurements in Jefferson County also apply to population exposures in the more densely populated portion of Shelby County, thereby eliminating the need for an additional CMZ.

4.5 Locate Sites

There are two options for the community-oriented monitoring approach for making comparisons to the annual $PM_{2.5}$ NAAQS. The network can either be constructed in terms of using: 1) individual community-oriented core sites; or 2) taking the spatial average of two or more eligible core sites in a well defined community monitoring zone. Existing sites within a CMZ are evaluated against the PM siting criteria in Section 5. Sites that do not meet those criteria for neighborhood or urban zones of representation are eliminated as potential compliance monitoring sites for comparison to annual standards, though they may be designated as daily compliance sites or SPM sites. Core $PM_{2.5}$ sites should include: 1) a population-oriented site with the highest expected community-oriented concentrations; 2) a site with high population density with poor air quality (high population exposure); and 3) a site collocated at a PAMS site, if the MPA is a PAMS area.

APPENDIX A

Answers to Review Exercises

Lesson 2

1. a
2. b
3. d
4. c
5. c
6. d
7. a
8. b
- 9.

- define concepts and terms of network design.
- summarize the availability and usage of existing resources for network design.
- demonstrate the methodology in practical applications.
- present a methodology for defining planning areas and selecting and evaluating monitoring sites in a network.

10.

- Twenty-four hour average $PM_{2.5}$ not to exceed $65 \mu\text{g}/\text{m}^3$ for a three-year average of annual 98th percentiles at any population-oriented monitoring site in a monitoring area.
- Three-year annual average $PM_{2.5}$ not to exceed $15 \mu\text{g}/\text{m}^3$ concentrations from a single community-oriented monitoring site or the spatial average of eligible community-oriented monitoring sites in a monitoring area.
- Twenty-four hour average PM_{10} not to exceed $150 \mu\text{g}/\text{m}^3$ for a three-year average of annual with percentiles at any monitoring site in a monitoring area.
- Three-year average PM_{10} not to exceed $50 \mu\text{g}/\text{m}^3$ for three annual average concentrations at any monitoring site in a monitoring area.

Lesson 3

1. less than $0.08 \mu\text{m}$
2. from $0.08 \mu\text{m}$ to $2.5 \mu\text{m}$
3. greater than $2.5 \mu\text{m}$

4. d

5. c

6. d

7. b

8. a

9.

- To determine representative concentrations in areas of high population density.
- To determine the impact on ambient pollution levels of significant sources or source categories.
- To determine general background concentration levels.
- To determine the extent of regional pollutant transport among populated areas; and in support of secondary standards.
- To determine the highest concentrations expected to occur in the area covered by the network.
- To determine the welfare-related impacts in more rural and remote areas such as visibility impairment and effects on vegetation.

10. c

11. b

12. a

13. f

14. e

15. b

16. a

17. d

18. a

Lesson 4

1. b
2. c
3. a
4. c
5. c
6. c
7. a
8. a
9. c
10. b
11. a

Lesson 5

1.
 - Identify political boundaries of populated areas.
 - Identify natural air basins.
 - Locate existing air quality monitoring sites.
 - Reconcile boundaries with existing planning areas.
2. a
3. a
4.
 - Locate emissions sources and population
 - Identify meteorological patterns
 - Compare pm concentrations.
 - Adjust cmzs to jurisdictional boundaries
 - Locate sites
5. b
6. d
7. b
8. a
9. b

Lesson 6

1. d
2. a
3. b
4. c

Lesson 7

1. d
2. a
3. a
4. b
5. a
6. b
7. a
8. d
9. a
10. d