NESCAUM
www.nescaum.org

The Clean Air Association of the Northeast States
101 Merrimac Street, 10th Floor Boston, MA 02114
Phone 617-259-2000 Fax 617-742-9162
Arthur N. Marin, Executive Director

March 24, 2005

Dr. Mary Ross
Office of Air Quality Planning and Standards – C539-01
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Dr. Rogene Henderson
Attention: Mr. Fred Butterfield, Designated Federal Officer
EPA Science Advisory Board (1400A)
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Re: NESCAUM Comments on January 2005 Second Draft PM Staff Paper

Dear Dr. Ross and Dr. Henderson:

The Northeast States for Coordinated Air Use Management (NESCAUM) appreciates the opportunity to provide comments on EPA's January 2005 Second Draft Staff Paper, "Review of the National Ambient Air Quality Standards for Particulate Matter: Policy Assessment of Scientific and Technical Information." Established in 1967, NESCAUM provides a forum for regional cooperation and the exchange of technical and policy information among air quality regulators in Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont.

Given the stringency of primary $PM_{2.5}$ standards we believe is necessary to protect public health across our region, NESCAUM advocates for a 24-hr $PM_{2.5}$ standard of 30 $\mu g/m^3$ (98^{th} percentile form) and an annual $PM_{2.5}$ standard of 12 $\mu g/m^3$. The NESCAUM Board—composed of the chiefs of the air bureaus and divisions in our eight member states—recognizes the considerable implications of promoting standards that will place the majority of the region's counties into $PM_{2.5}$ nonattainment. Nonetheless, we believe this is the correct public health action. We have conducted analyses to support our primary standard recommendation, as provided in the attached materials. NESCAUM appreciates your willingness to consider these comments as you move forward on this important issue.

Sincerely,

Arthur N. Marin
Executive Director

cc: NESCAUM Directors, Air Quality and Public Health Committee, Attainment Planning Committee

NESCAUM primary standard $PM_{2.5}$ analyses*

Our recommendation for more stringent $PM_{2.5}$ primary standards is based on analyses conducted by NESCAUM of national and northeastern U.S. ambient monitoring data and of northeastern U.S. demographic data.

Our analysis of a range of $PM_{2.5}$ standard levels and forms is premised on $PM_{2.5}$ concentrations determined by EPA's PM Staff Paper to have possible human health significance in relation to standard setting. Our demographic analysis of population density, age, and disease prevalence is premised on the relevance of these data as indicators of exposure to urban $PM_{2.5}$ concentrations (population density) and as determinants of subgroups susceptible to fine particles (age and disease prevalence). We assume that compliance with more stringent $PM_{2.5}$ standards would benefit public health.

In summary, our analyses have found:

1. A change in either annual or 24-hr standard levels (and 24-hr percentile forms) shifts distribution curves and shaves maxima. Depending on the combination of annual and 24-hr standards and forms used, a substantial percentage of monitors in the U.S. may or may not meet alternative standard levels. Annual standards may fail to constrain 24-hr levels; 24-hr standards may fail to constrain annual levels. A suitable combination of appropriately stringent annual and 24-hr standards has optimum controlling effect throughout the distribution of $PM_{2.5}$ levels. (Figures 1-2 and Tables 1-2)

2. 24-hr maxima vary according to the stringency of the 24-hr standard and form, which can be suitably protective if the standard level is adequately stringent. In the NESCAUM region, the majority of excluded points above the 24-hr standard 98^{th} and 99^{th} forms are within 5 $\mu g/m^3$. The impact of high peak day exemptions due to forest fires on annual and 24-hr levels was found to be significant in some areas. (Tables 3-5)

3. Subdaily peak $PM_{2.5}$ levels occur that the 24-hr averaging metric smoothes, masking exposure variability. Hourly averaged $PM_{2.5}$ levels vary across days, weeks, and seasons. A 24-hr average standard can constrain subdaily maximum 3-, 4-, and 6-hr averages. The more stringent the 24-hr average standard, the lower the subdaily maximum levels will be. (Figures 3-6, Table 6)

4. Subgroups potentially susceptible to $PM_{2.5}$ in the NESCAUM region include age groups 0-17 and 65+ yrs (38% of the total population); adults with cardiopulmonary or diabetes health conditions (4-18% of adult population); and children with respiratory allergies or lifetime asthma (12-15% of children population). (Tables 6-7)

5. The majority of persons in the NESCAUM 8-state region live in densely populated urban areas, many of which experience elevated PM levels and heightened exposure scenarios. The population density of this region is among the highest in the nation, as 5 of 8 states (NJ, RI,

MA, CT, and NY) are among the 6 most densely populated states in the U.S. The region's urban areas consist of 6% of the total land mass and about 30 million (72%) of the region's total population of 41.3 million persons. More than 70% of all age groups live in urban areas. Age groups susceptible to PM exposure (ages 0-17 and 65+ yrs) living in urban areas comprised 27% of the region's total population. (Figure 7 and Table 8)

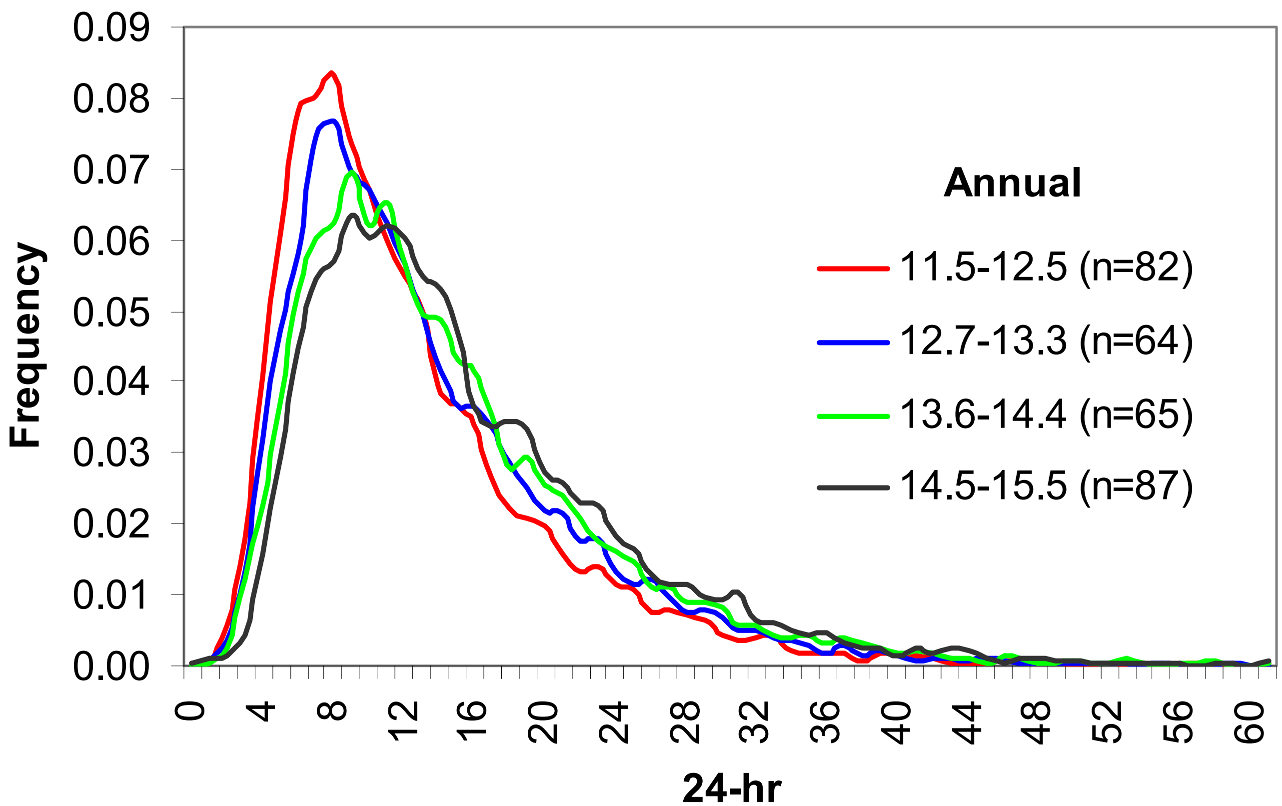
6. Depending on the combination of $PM_{2.5}$ primary standards chosen by EPA, 16% of the NESCAUM region population lives in non-attainment areas, the majority of which are urban. With a 24-hr (98^{th}) / annual standard of 30 / 12 $\mu g/m^3$, 84% of the population would live in non-attainment areas and would therefore benefit from compliance control measures. With an EPA-recommended standard suite of 24-hr (98^{th}) / annual standard of 40 / 14 $\mu g/m^3$, only 29% of the population would live in non-attainment areas. With an EPA-recommended standard suite of 24-hr (98^{th}) / annual standard of 35 / 15 $\mu g/m^3$, only 34% of the population would live in non-attainment. (Figure 8)

7. Depending on the combination of $PM_{2.5}$ primary standards chosen by EPA, about five times more people in potentially susceptible populations based on age group and health status would especially benefit from $PM_{2.5}$ emission control strategies than at the current 24-hr (98^{th}) / annual standard suite of 15 / 65 $\mu g/m^3$. Compliance with a revised 24-hr (98^{th}) / annual standard of 30 / 12 $\mu g/m^3$ would benefit about 84% of the region's total population, and would especially benefit 8.5 million 0-17 year olds, 4.5 million 65+ year olds, 1.6 million adults with diabetes, 2.7 million adults with heart disease, 3.3 million adults with lifetime reported asthma, 1 million adults with chronic bronchitis, 3.8 million adults with sinusitis, 1.3 million children with lifetime asthma, and 1 million children with respiratory allergies. (Table 9)

*** Note: Some of the information presented in these analyses is part of manuscripts submitted to *Environmental Health Perspectives* and to the *Journal of the Air & Waste Management Association* for possible publication.**

A change in either annual or 24-hr standard levels (and 24-hr percentile forms) shifts distribution curves and shaves maxima.

Figure 1a: Distribution of annual $PM_{2.5}$ ranges (µg/m^3)
(2000-2002 FRM 8 NESCAUM states, DC, DE, MD, PA)



Figures 1a-c show the distribution for annual and 24-hr avg (98th or 99th form). Each distribution covers the entire data range (with the area under the curve equaling one) and is normalized to reflect the total number of monitored days in every grouping.

The figures demonstrate that as either annual or 24-hr standards and forms are tightened, the entire curve (including tail) shifts toward the left, decreasing short-term and longer-term mass averages.

Figure 1b: Distribution of 24-hr (98th or 99th form) $PM_{2.5}$ ranges ($\mu g/m^3$)

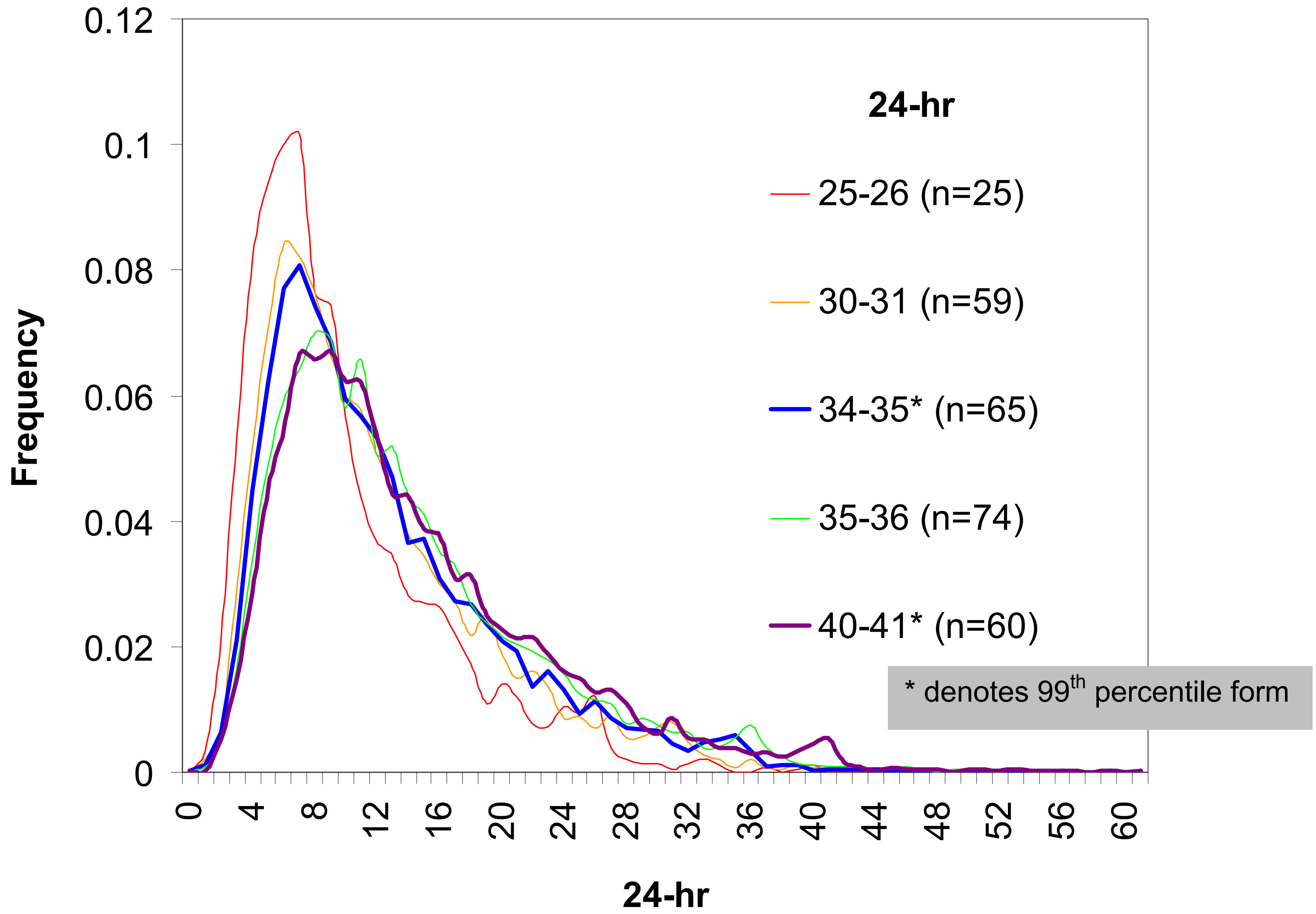


Figure 1c: Distribution of annual and 24-hr (98th form) $PM_{2.5}$ ranges (µg/m³)

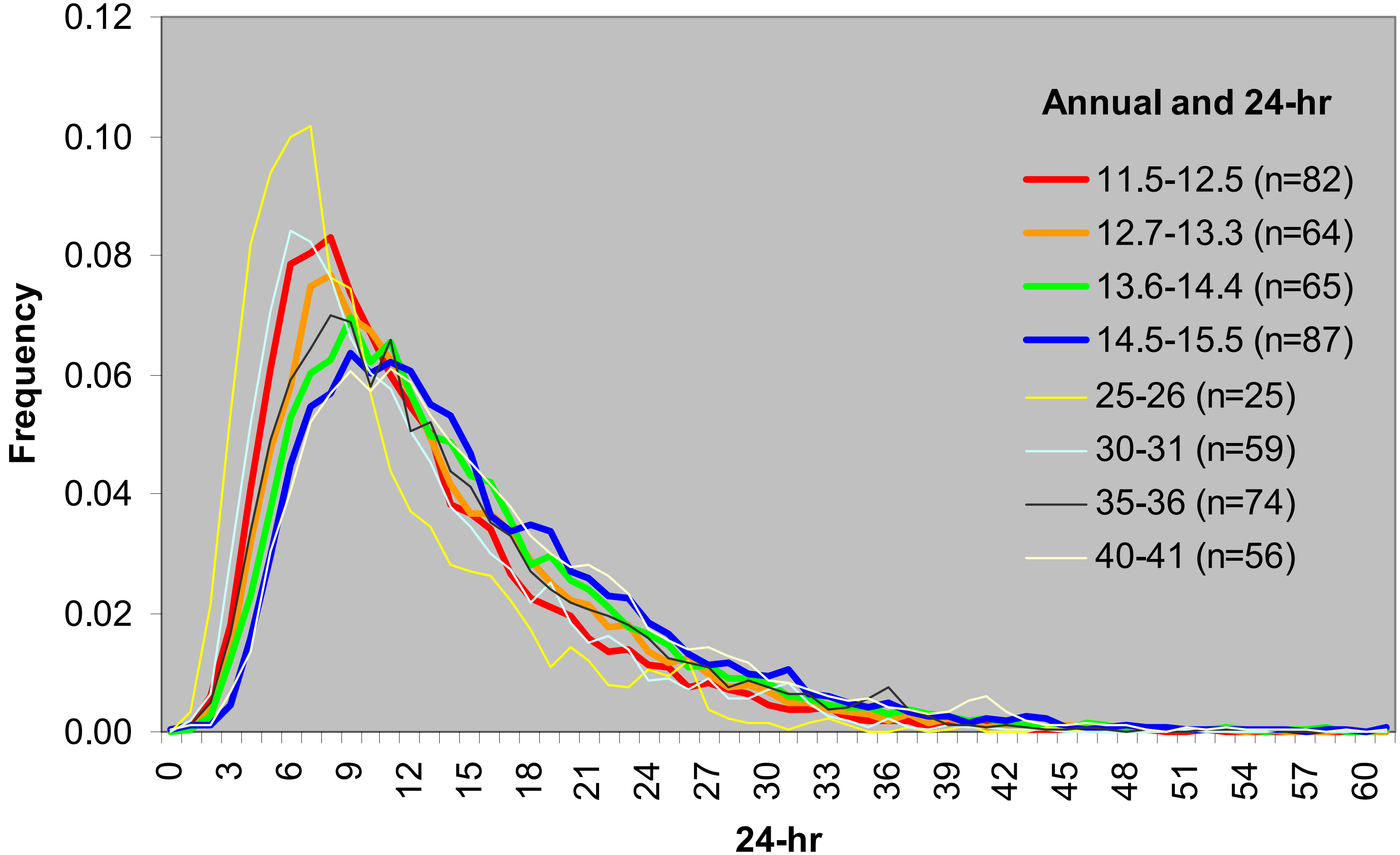


Table 1: Equivalent $PM_{2.5}$ primary standards and forms ($\mu g/m^3$)

Annual	**24-hr 98th form**	**24-hr 99th form**
11.2	31	35
12	33	37
13	35	39
13.5	36	40
14	37	41
15	39	43

Using the same data set plotted in Figure 1, **Table 1** shows equivalent $PM_{2.5}$ values for the annual and 24-hr forms. A 99th form equivalent 98th form is 4 $\mu g/m^3$ more stringent.

For example, using a 99th form of 40 $\mu g/m^3$ yields an equivalent 98th form of 36 $\mu g/m^3$ and effective annual of 13.5 $\mu g/m^3$.

Depending on the combination of annual and 24-hr standards and forms used, a substantial percentage of monitors in the U.S. may or may not meet alternative standard levels. Annual standards may fail to constrain 24-hr levels; 24-hr standards may fail to constrain annual levels.

Figure 2a: Frequency of alternative 24-hr and annual $PM_{2.5}$ stringency ranges for monitoring sites in U.S. ($\mu g/m^3$) (FRM country-wide monitors* 2000-2002)

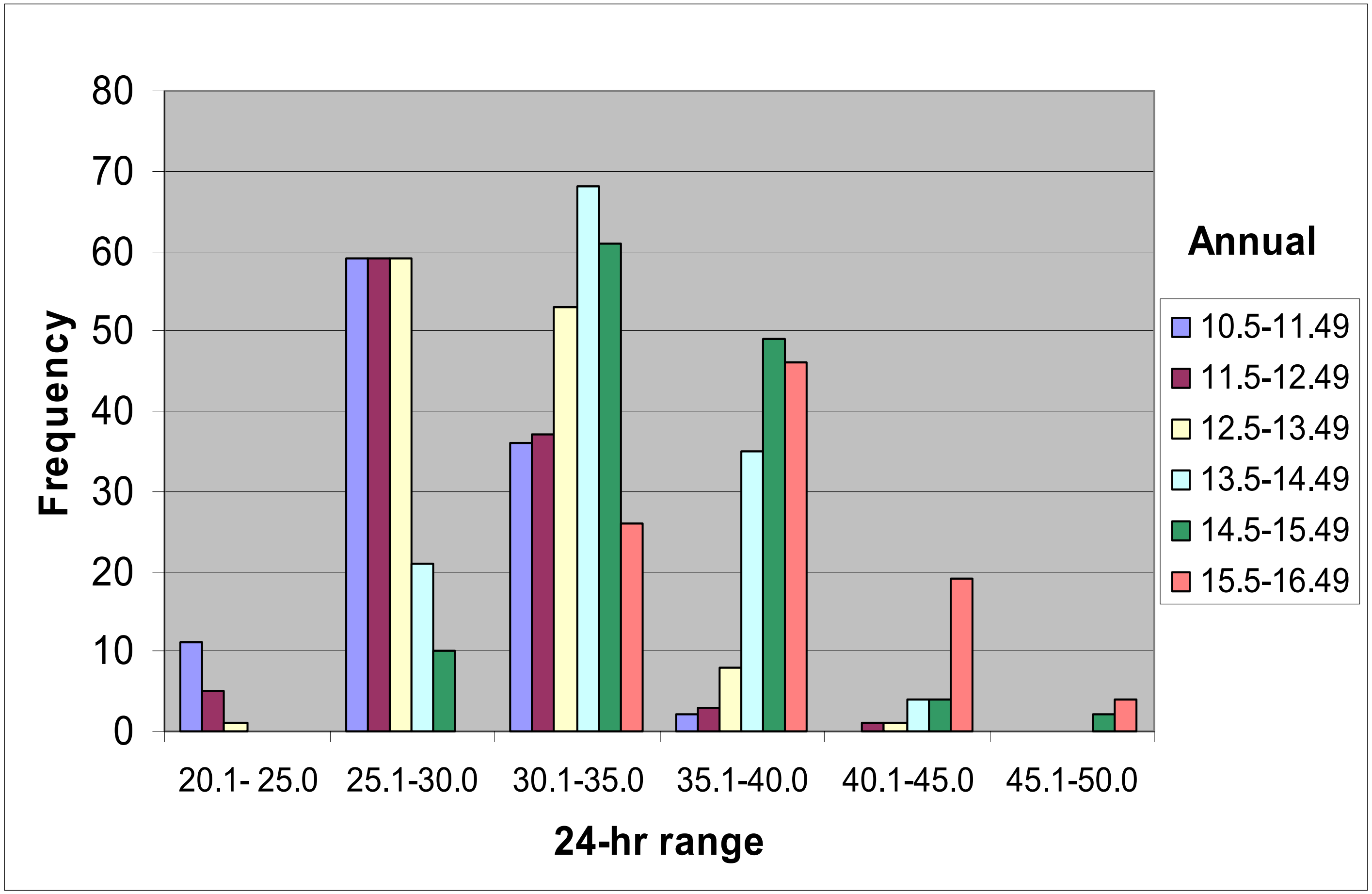


Figure 2a plots the site by site relationship between the 24-hr avg (98^{th} form) and annual mean to track how changes in either metric influence stringency across U.S. monitors. Variability occurs across the average of all 3 years (2000-2002).

For example, sites with an annual range of 11.5-12.49 $\mu g/m^3$ experience 24-hr avgs predominately ranging from 25.1 -35 $\mu g/m^3$. Sites with an annual range of 14.5-15.49 $\mu g/m^3$ experience 24-hr avgs predominately ranging from 30.1-40 $\mu g/m^3$.

Figure 2b: Frequency of alternative annual and 24-hr $PM_{2.5}$ stringency ranges for monitoring sites in U.S. ($\mu g/m^3$) (FRM country-wide monitors* 2000-2002)

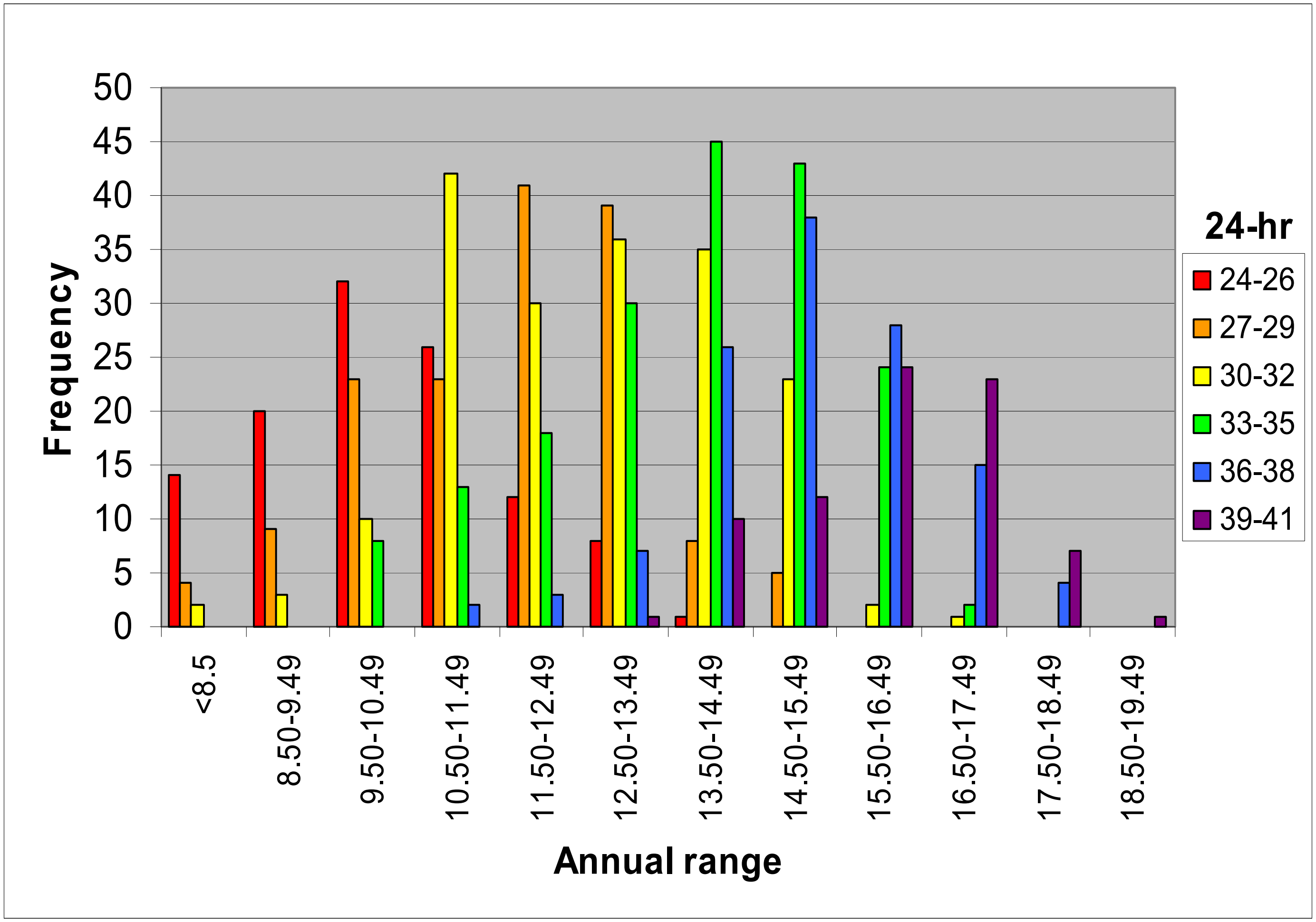


Figure 2b plots the site by site relationship between the annual mean and 24-hr avg (98th form) to track how changes in either metric influence stringency across U.S. monitors. Variability occurs across the average of all 3 years (2000-2002).

For example, sites with a 24-hr range of 36-38 $\mu g/m^3$ experience annual means predominately ranging from 13.5-17.49 $\mu g/m^3$. Sites with a 24-hr range of 30-32 $\mu g/m^3$ experience annual means predominately ranging from 10.5-15.49 $\mu g/m^3$.

* Note: These represent a subset of nearly 1000 monitors across the country. Data analysis showed in certain areas of the western U.S. a bifurcated data distribution as determined by the ratio of the daily to annual monitored value. The majority of these monitors followed the broad trend identified in eastern states. Western sites with a 24-hr:annual ratio greater than 3.5 were excluded from this analysis.

Table 2: Percentage of monitors that would meet a potential annual $PM_{2.5}$ standard level but not meet the potential 24-hr 98th or 99th percentile form standard level (2000-2002 FRM 8 NESCAUM states, DC, DE, MD, PA)

Annual Std (µg/m³)	24-hr Std (µg/m³)	98th form % Monitors	99th form % Monitors
12	40	1.5%	7.4%
	35	1.5%	23.5%
	30	42.6%	73.5%
	25	85.3%	98.5%
	20	100.0%	100.0%
13	40	1.1%	7.7%
	35	4.4%	35.2%
	30	54.9%	80.2%
	25	89.0%	98.9%
	20	100.0%	100.0%
14	40	0.8%	19.5%
	35	15.3%	50.0%
	30	65.3%	84.7%
	25	91.5%	99.2%
	20	100.0%	100.0%
15	40	2.0%	27.7%
	35	29.1%	58.8%
	30	72.3%	87.8%
	25	93.2%	99.3%
	20	100.0%	100.0%

A suitable combination of appropriately stringent annual and 24-hr standards has optimum controlling effect throughout the distribution of $PM_{2.5}$ levels.

Table 2 provides the percentage of monitors that would meet an annual standard but would not meet a 24-hr standard (98th or 99th form) for specific annual/24-hr groupings.

For example, at the 15 µg/m³ annual and 40 µg/m³ 24-hr grouping, 2.0 % of monitors do not meet the 24-hr (98th form) but do meet the annual standard. Conversely, at the15/20 annual/24-hr standard grouping, none of the monitors that meet the potential annual standard meet the potential 24-hr standard.

Table 3: Predicted maximum $PM_{2.5}$ values (of expected 98th percentile exceedances) for corresponding potential 24-hr values (FRM Regions 1, 2, and 3: 2000-2002)

Potential 24-hr value (µg/m^3)	**Percent of sites with corresponding predicted max value**			
	50% (µg/m^3)	85% (µg/m^3)	95% (µg/m^3)	100% (µg/m^3)
15	19	23	25	34
20	25	30	34	46
25	31	38	42	57
30	38	45	51	69
35	44	53	59	80
40	50	60	67	92
45	56	68	76	103
50	63	75	84	115
55	69	83	93	126
60	75	90	101	138
65	81	98	110	149

24-hr maxima vary according to the stringency of the 24-hr standard and form, which can be suitably protective if the standard level is adequately stringent.

Table 3 predicts the relationship between a potential 24-hr average standard level and its corresponding excluded maxima (up to 7 days per year) above the 98th percentile. The predicted values were generated from the ratio between actual maximum and daily values. The left column gives a 24-hr value that might be found at a monitored site. The columns to the right show where 50%, 85%, 95%, and 100% of the monitoring sites have corresponding maximum values at or below the listed level.

For example, if we assume that a site meets a 24-hr alternative standard of 30 µg/m^3, then 7 days in a year the site will experience $PM_{2.5}$ levels between 30 and 69 µg/m^3, but for 95% of the monitors meeting that 24-hr alternative standard, the range will be from 30 to 51 µg/m^3. To keep the maximum 24-hr $PM_{2.5}$ at 95% of sites under 26 µg/m^3 (i.e., 25 µg/m^3), a 24-hr 98th percentile alternative standard of 15 µg/m^3 must be met.

In the NESCAUM region, the majority of excluded points above the 24-hr standard 98th and 99th forms are within 5 µg/m^3.

Table 4: Number of days $PM_{2.5}$ values exceed 98th or 99th form within or above 5 µg/m^3 of the 24-hr level (2000-2002 FRM Regions 1, 2, 3)

	Number of days above 24-hr standard			
	98th Percentile Form		99th Percentile Form	
24-hr avg conc (µg/m^3)	# days ≤ 5 µg/m^3 of level	# days > 5 µg/m^3 of level	# days ≤ 5 µg/m^3 of level	# days > 5 µg/m^3 of level
25-26	3.9	3.1		
27-29	4.3	2.7		
30-31	5.0	2.0	2.9	1.1
32-33	4.3	2.7	3.0	1.0
34-35	4.8	2.2	3.1	0.9
35-36	4.6	2.4		
36-37	4.1	2.9	2.9	1.1
38-39	3.9	3.1	2.7	1.3
40-41	4.4	2.6	2.7	1.3
Average # days	4.4	2.6	2.9	1.1

More than half the days > standard are within 5 µg/m^3 of the standard for both 98th and 99th forms, corresponding to fewer than 3 days and 1 day > 5 µg/m^3, for each form respectively.

The impact of high peak day exemptions due to forest fires on annual and 24-hr levels was found to be significant in some areas.

Table 5: Reduction in annual and 24-hr $PM_{2.5}$ from peak concentration exemptions (2002 FRM Regions 1, 2, part of 3)

	Annual (µg/m^3)	24-hr (µg/m^3)
Maximum	1.03	23.60
95th percentile	0.74	11.56
75th percentile	0.58	4.50
Median	0.51	1.90
Average	0.48	3.36
25th percentile	0.38	0.70
5th percentile	0.17	0.00
Minimum	0.08	0.00

Table 5 shows the potential impact of peak $PM_{2.5}$ concentration exemptions in reporting annual and 24-hr levels. For 129 out of 192 sites that exempted $PM_{2.5}$ data, annual means were as much as 1 µg/m^3 lower and on average about 0.5 µg/m^3 lower. For the 24-hr average, data removal resulted in a median change of about 2 µg/m^3. The maximum change was almost 24 µg/m^3. The majority of the values above the 98th percentile were reasonably close to the 98th form. However, maximum values were more extreme.

Subdaily $PM_{2.5}$ peak levels occur that the 24-hr averaging metric smoothes, masking exposure variability.

Figure 3: 24-hr and maximum 3-hr $PM_{2.5}$ concentrations for New Haven CT (1997-2002 TEOM)*

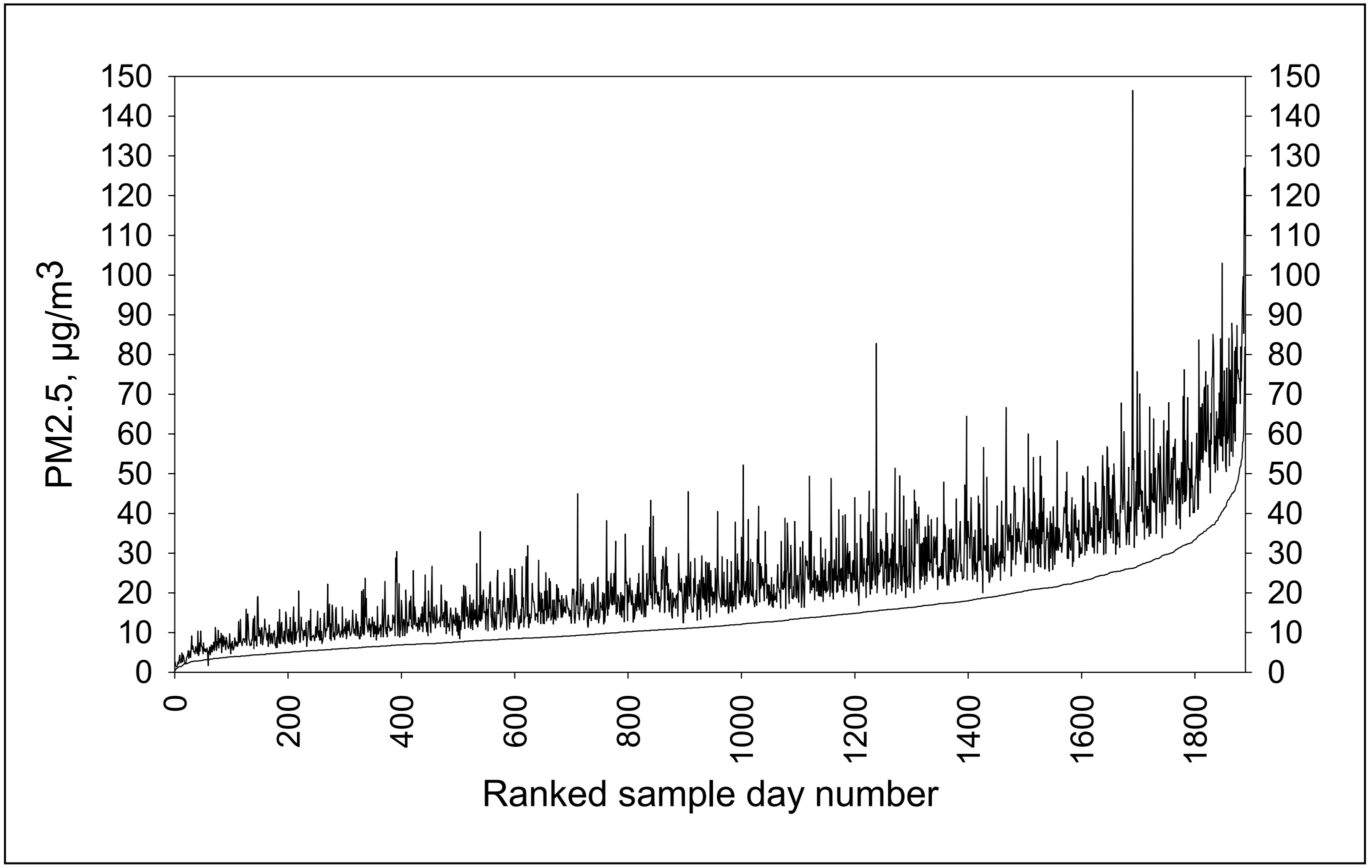


Figure 3 plots ascending 24-hr averages relative to corresponding 3-hr max averages for New Haven, CT.

* Note: We recognize the potential for continuous TEOM data to underestimate $PM_{2.5}$ relative to "FRM-like" levels because of loss of semi-volatile mass.

Figure 4: Summer and winter hourly averaged mass (μg/m^3) (right axis) compared to percentage of time 1-hr $PM_{2.5}$ averages >30 μg/m^3 (left axis) from midnight – midnight, by weekend (WE) and weekday (WD), New Haven CT (1997-2002 TEOM)

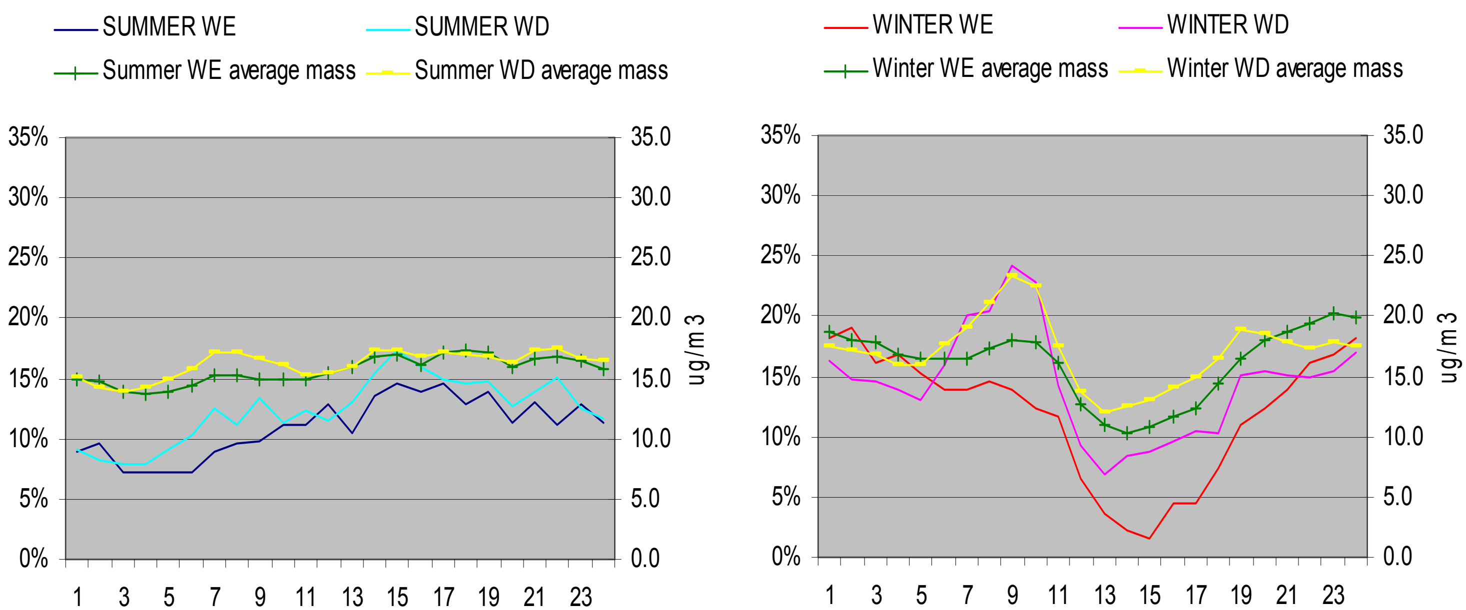
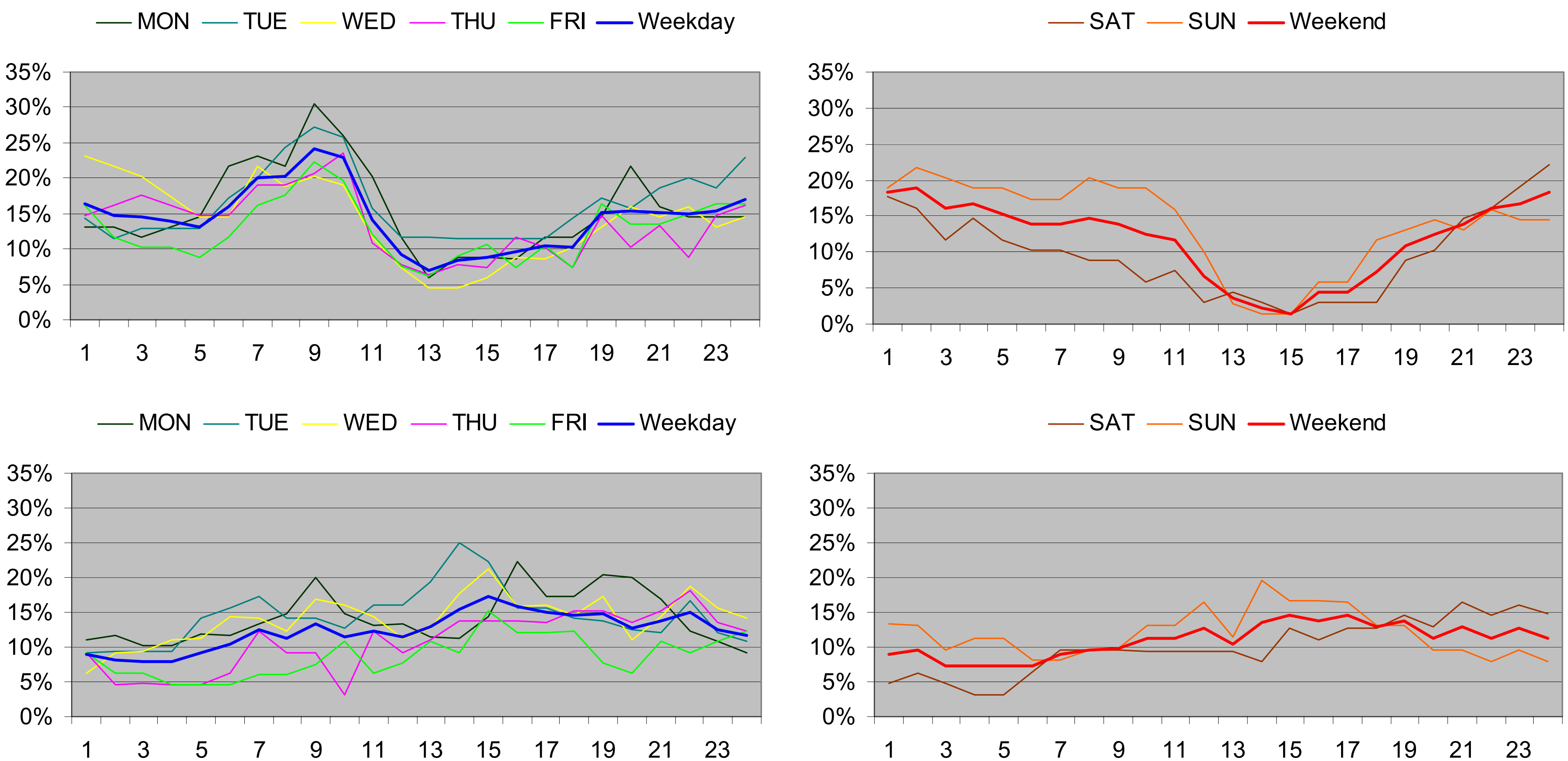


Figure 4 compares the average mass $PM_{2.5}$ concentration for each hour of the day with the percent of time that corresponding 1-hr levels are above a 30 μg/m^3 baseline. The hourly averaged mass levels are the average mass concentration for each hour of the day during summer/winter weekend/weekday periods. The graphs show that a significant percentage of 1-hr levels above the 30 μg/m^3 baseline exceed their corresponding average mass concentrations for each hour. For example, winter 1-hr weekday (WD) averages above 30 μg/m^3 range from about 7% to 24% of hours across a day while hourly averaged mass levels range from only about 12 to 24 μg/m^3. Summer 1-hr weekday averages above 30 μg/m^3 range from about 7% to 17% while hourly averaged mass levels range from only about 14 to 17 μg/m^3. This analysis suggests that normative averaging techniques may mask subdaily exposure variability.

Figure 5 plots hourly averages by day of week and season above a prescribed baseline.

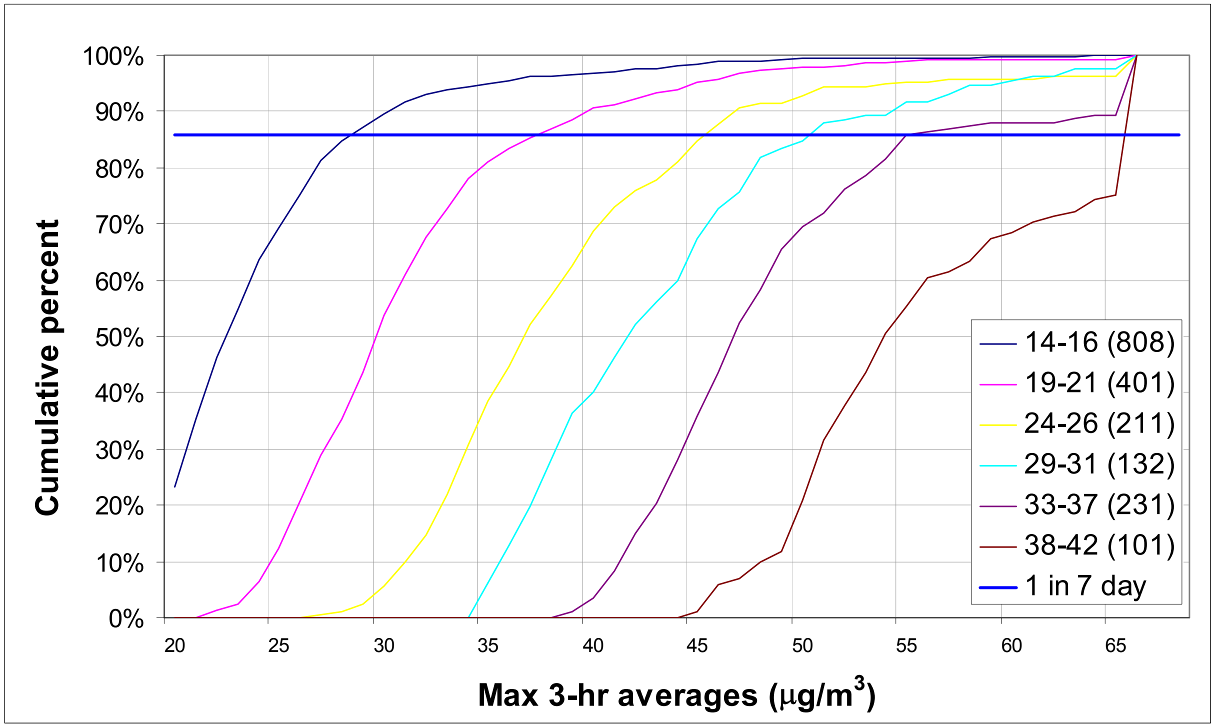
Hourly averaged $PM_{2.5}$ levels vary across days, weeks, and seasons.

Figure 5: Percentage of time 1-hr $PM_{2.5}$ averages >30 μg/m^3, midnight – midnight by day of week, winter (top) and summer (bottom), New Haven CT (1997-2002 TEOM)



A 24-hr average standard can constrain subdaily maximum 3-, 4-, and 6-hr averages. The more stringent the 24-hr average standard, the lower the subdaily maximum levels will be.

Figure 6: Relationship of 24-hr and maximum 3-hr averages (2001 Region 1, 2, and border states)



The cumulative frequency plot in **Figure 6** shows the distribution of max 3-hr averages associated with 24-hr averages within a discrete range. These daily ranges are centered around 5 µg/m^3 breakpoints of 15, 20, 25, 30, 35 and 40. The number of days about each of these values is included in parentheses in the figure legend. Cumulative frequency of the 3-hr max values are plotted for each of the 24-hr average bins. For discussion purposes, the solid horizontal blue line demarks a one day a week point. An estimate of the maximum 3-hr max level experienced at a monitor once per week can be read from the graph by dropping a vertical line from the intersection of this solid blue line with the 24-hr average cumulative curve. For example, the pink line, which represents days around a 20 µg/m^3 daily average will experience a 3-hr max level of at least 38 µg/m^3 once per week. Similar behavior was observed for 4- and 6-hr averages.

A significant percentage of the NESCAUM region population is potentially susceptible to $PM_{2.5}$ based on age group and on preexisting health condition.

While subpopulation numbers differ according to how one defines susceptible persons—and recognizing that few studies have quantified the extent to which sensitivity to PM varies within subgroups—the number and percent of sensitive persons in the NESCAUM region can be estimated based on age group and disease prevalence, as shown in **Tables 6 and 7.** Thirty-eight percent of the region's total population is aged 0-17 and 65+; 4-18% of adults have cardiopulmonary or diabetes health conditions; and 12-15% of children have respiratory allergies or lifetime asthma.

Table 6: Number and % of age subgroups living in the NESCAUM region.

Age group (yrs)	Number	%
0-2	1,574,903	4
3-17	8,550,659	21
≥65	5,453,117	13
Total (0-17, ≥65)	15,578,679	38
18-64	25,734,645	62
Total (all ages)	41,313,324	100

Table 7: Number and % of adults and children with specific pre-existing disease conditions living in the northeastern U.S.

Age group and health condition	Prevalence rate (%)	Number of persons
≥18 yrs		31,187,762
Sinusitis (past 12 months)	14.7	4,584,601
Asthma (ever)	12.8	3,992,034
Chronic bronchitis (past 12 months)	3.9	1,216,323
Hypertension (ever)	17.9	5,582,609
Heart disease (ever)	10.4	3,243,527
Diabetes (ever)	6.2	1,933,641
0-17 yrs		10,125,562
Respiratory allergies (past 12 months)	12.2	1,235,319
Asthma (ever)	14.8	1,498,583

Seventy-two percent of the NESCAUM region's population lives in 6% of the land mass—urban areas that experience elevated annual and 24-hr $PM_{2.5}$ levels.

Figure 7: U.S. Census tract population densities of Northeast states

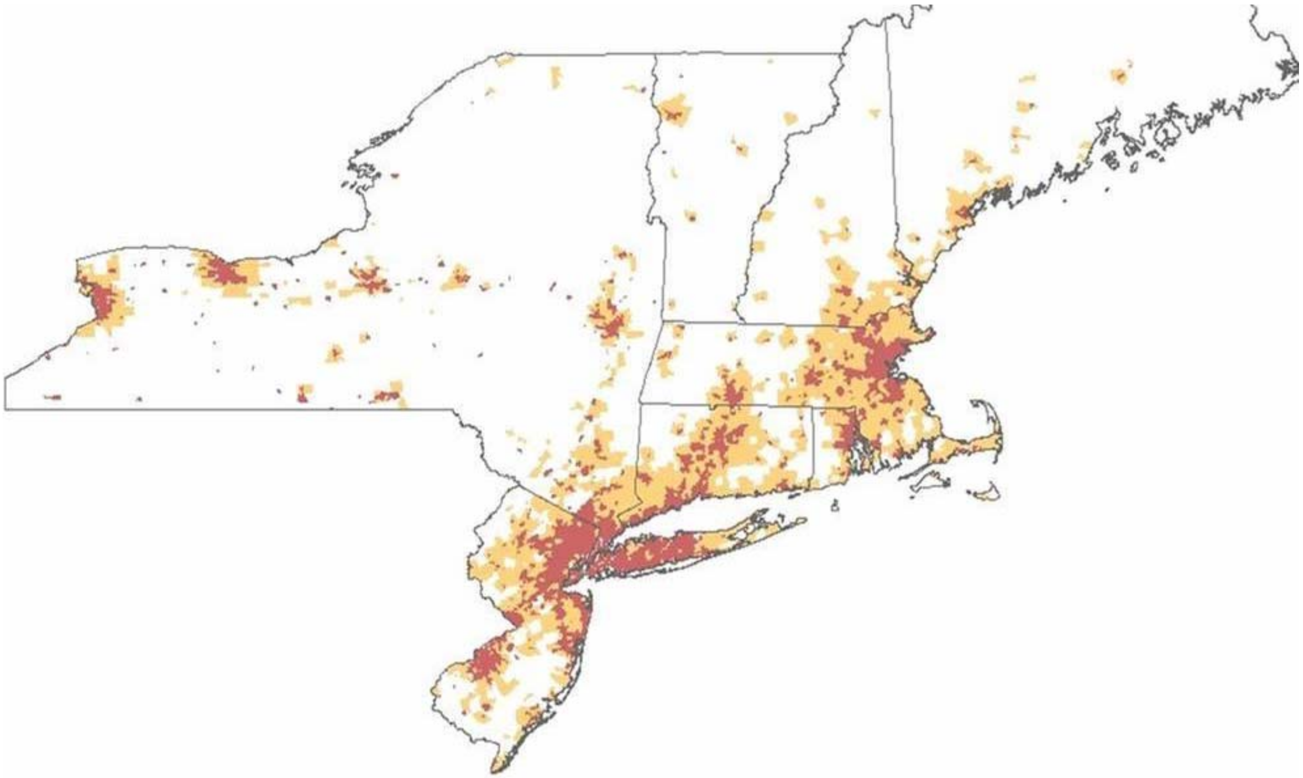


Figure 7 shows the population density of the 8-state NESCAUM region. The region's urban areas defined as having 2000 U.S. Census tract population densities greater than 1,000 persons/miles^2 (shown in red), consisted of 6% of the total land mass and were home to about 30 million persons or 72% of the region's total population of 41.3 million persons. Areas with a population density greater than 200 persons/miles^2 (shown in yellow) consist of 18% of the total land mass and are home to about 88% of the population.

Seventy-one to 73% of all age groups in the NESCAUM region live in densely populated urban areas.

Table 8: Distribution of population age groups by non-urban and urban population density scales in the northeastern U.S.

	Population density (persons/mile^2 land area)				
	0-1,000 (94% of total land mass)		>1,000 (6% of total land mass)		
Age (yrs)	Number	% Total	Number	% Total	% Age group
0-17	2,915,526	7	7,210,036	17	71
18-64	7,008,390	17	18,726,255	45	73
≥65	1,460,005	4	3,993,112	10	71
Total	11,383,921	28	29,929,403	72	72

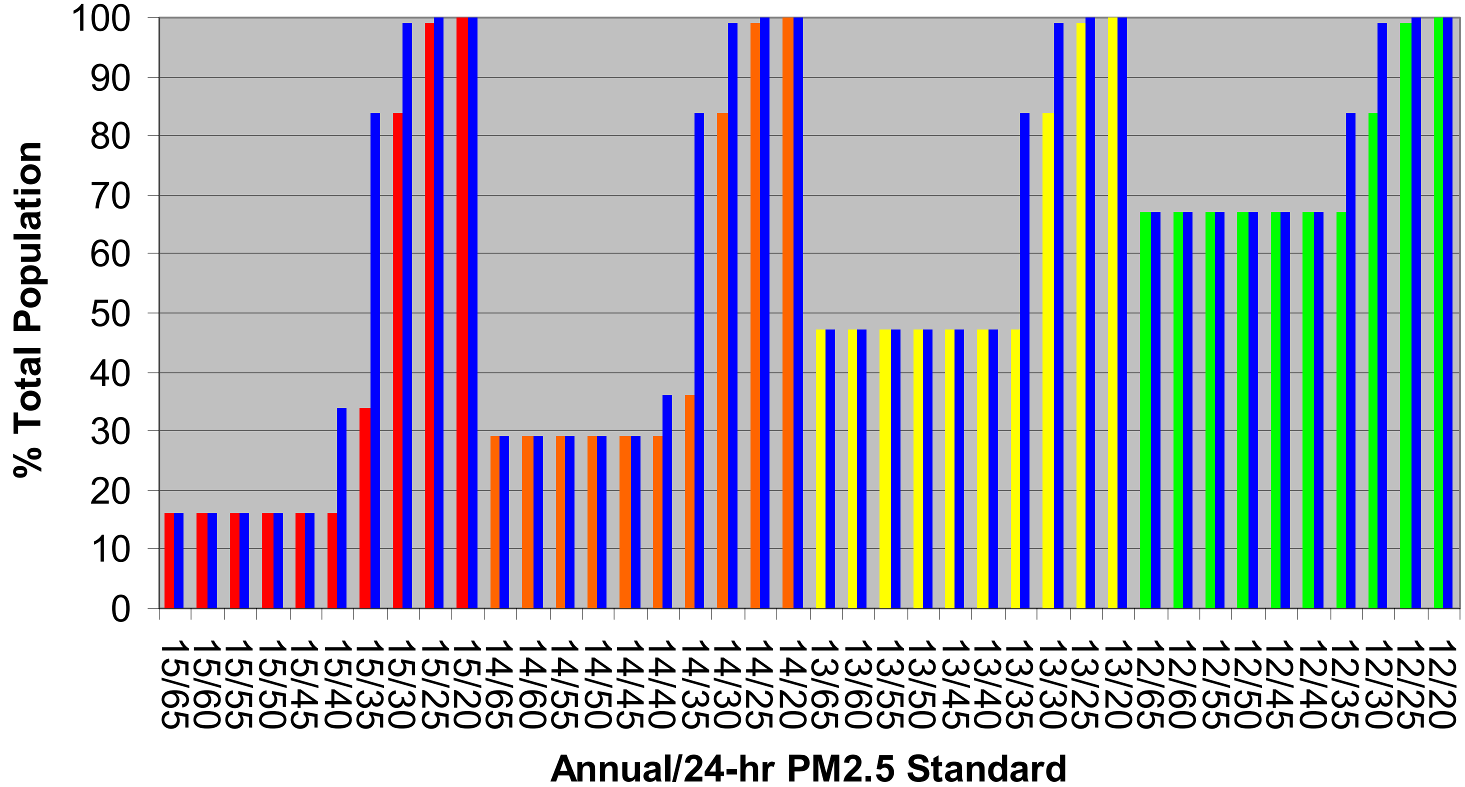
As shown in **Table 8**, in every age group more than 70% of the population (or about 30 million persons) live in areas with densities greater than 1,000 persons per mile^2. Age groups susceptible to PM exposure (ages 0-17 and ≥65 yrs) living in urban areas comprised 27% of the region's total population.

Depending on the combination of $PM_{2.5}$ standards chosen by EPA, NESCAUM region counties with a substantial fraction of the region's population and susceptible subgroups may be below or above alternative levels.

Figure 8 (next page) shows the percent total population in the NESCAUM region that would benefit from compliance with $PM_{2.5}$ levels less or greater than various combinations of annual and 24-hr (98th percentile form and 99th form) concentrations. The analysis is based on 150 counties in Regions 1 and 2, where the highest annual or 24-hr interpolated values were used to assign $PM_{2.5}$ levels to the 80 counties without monitoring values for the 3-year period. Monitoring data were used from within and immediately outside the NESCAUM region.

By meeting the current annual / 24-hr (98th form) standard of 15/65 $\mu g/m^3$, the requirement to reduce emissions of $PM_{2.5}$ and its precursors results in 16% of the region's population benefiting from $PM_{2.5}$ emission control strategies. By meeting an annual / 24-hr (98th form) standard of 15/35 $\mu g/m^3$, 34% of the region's population would benefit. With an annual / 24-hr (98th form) standard of 15/30 $\mu g/m^3$, 84% of the region's population would benefit from more stringent standards, or 68% more than the current standard.

Figure 8: Percent total population in the NESCAUM region that would benefit from compliance with $PM_{2.5}$ levels less or greater than alternative combinations of annual and 24-hr standards ($\mu g/m^3$)
Red, orange, yellow, and green denote alternative annual / 24-hr (98th form) levels. Blue denotes corresponding 24-hr 99th form levels.*



* Note: 98th percentile std level = (99th percentile standard) – (4.0-4.6) $\mu g/m^3$. We have rounded up to 5 $\mu g/m^3$. For example, a 99th value of 35 $\mu g/m^3$ = a 98th value of 30 $\mu g/m^3$. (35 – 5 = 30)

Table 9: Percent and number of NESCAUM region population susceptible subgroups that would especially benefit from compliance with alternative annual / 24-hr EPA (January 2005) and NESCAUM (November 2004) recommended $PM_{2.5}$ standards

		EPA current annual / 24-hr $PM_{2.5}$ std ($\mu g/m^3$)	EPA least stringent recommended annual / 24-hr $PM_{2.5}$ std ($\mu g/m^3$)		EPA most stringent recommended annual / 24-hr $PM_{2.5}$ std ($\mu g/m^3$)		NESCAUM recommended annual / 24-hr $PM_{2.5}$ std ($\mu g/m^3$)
		15/65 (98th)	**15/35 (98th)**	**14/40 (98th)**	**15/25 (99th)**	**12/35 (99th)**	**12/30 (98th)**
Category	Total persons	persons > std	persons > std	persons > std	persons > std	persons > std	persons > std
	100%	16%	34%	29%	100%	84%	84%
All ages	41,313,324	6,677,410	14,148,509	12,126,418	41,313,324	34,505,602	34,505,602
Age 0-17	10,125,562	1,638,879	3,502,079	2,994,743	10,125,562	8,502,302	8,502,302
Age 65+	5,453,117	773,092	1,752,154	1,471,943	5,453,117	4,538,140	4,538,140
Diabetes (age 18+)	1,933,641	312,389	660,079	566,164	1,933,641	1,612,205	1,612,205
Heart disease (age 18+)	3,243,527	524,007	1,107,229	949,694	3,243,527	2,704,343	2,704,343
Lifetime asthma (age 18+)	3,992,034	644,932	1,362,743	1,168,854	3,992,034	3,328,422	3,328,422
Sinusitis (age 18+)	4,584,601	740,664	1,565,025	1,342,356	4,584,601	3,822,485	3,822,485
Chronic bronchitis (age 18+)	1,216,323	196,503	415,211	356,135	1,216,323	1,014,129	1,014,129
Lifetime asthma (age 0-17)	1,498,583	242,554	518,308	443,222	1,498,583	1,258,341	1,258,341
Respiratory allergy (age 0-17)	1,235,319	199,943	427,254	365,359	1,235,319	1,037,281	1,037,281

Table 9 shows susceptible subgroups by age and disease status that would especially benefit from compliance with $PM_{2.5}$ levels less or greater than alternative combinations of annual and 24-hr average (98th form) concentrations. The analysis uniformly applies U.S. CDC prevalence rates for the northeastern U.S. for selected health conditions to the number of persons living in areas with $PM_{2.5}$ concentrations above each annual / 24-hr standard combination.

Analysis methods

Federal Reference Method (FRM) $PM_{2.5}$ air pollution data from 2000, 2001, and 2002 were obtained from EPA's Air Quality System in August 2003 from 127 FRM monitors in EPA Region 1 (6 New England states) and Region 2 (NJ and NY), 65 FRM monitors outside these regions in bordering states (DE, DC, MD, PA), and 3 Interagency Monitoring of Protected Visual Environments (IMPROVE) sites in Regions 1 and 2. Countrywide data for the years 2000-2002 were obtained from http://www.epa.gov/air/data/index.html.

Design values were calculated in adherence with EPA's criteria for determination. Analysis of 99^{th} percentile values used the same NESCAUM and EPA countrywide datasets. We used 0.99 rather than 0.98 to determine which measured rank should be the 99^{th} for each year before calculating 3-year averages. Within the 2000-2002 period, 192 PM monitoring sites had data in all 12 quarters. Data flagged with the forest fire exemption for 2002 were removed. Over 75% of the 192 sites had better than 50% data capture within each quarter. Data completeness affecting the remaining sites was primarily isolated to 1 quarter. For sites with collocated monitors, the primary monitor at a site was used to determine the PM2.5 concentration (27 pairs of 192 monitors). Although less than half of the primary monitors satisfied the 75% data completeness criteria, no substitution from collocated monitors was attempted.

Analysis of the FRM database indicates a reasonable representation of the actual structure of 24-hour data used to establish annual and 24-hour standard relationships. Eighty-one sites meeting EPA's strict 75% completeness requirement for 12 consecutive quarters were compared to 111 sites that did not meet completeness requirements. Regression equations and slopes between the two monitoring data sets were statistically indistinguishable. The regression for the subset of monitors with complete data was $y=1.86x + 10.43$ ($R2=0.76$). The regression for the subset of monitors with incomplete data was $y=1.82x + 10.90$ ($R2=0.78$). One data point was excluded from the linear regression due to its undue influence by virtue of its extreme value pair. Inclusion of this point changed the regression to $y=2.00x + 8.79$ (although this slope is also statistically equivalent to that of the incomplete data).

In order to estimate the number of persons living in counties not likely to meet different combinations of alternative annual and 24-hour PM2.5 standards, 3-year average annual and 24-hour design values were calculated for all counties (150) in the 8-state study area and integrated with 2000 U.S. Census county-level population data using ArcGIS v8.2 software. Design values for the 70 counties with monitors were assigned from the highest monitored levels in each county for 2000-2002. Design values for 80 counties lacking monitors were generated by interpolating county-level monitored data from 104 monitors within the 8-state study region and 61 monitors outside the region for border counties. An interpolation scheme was employed using inverse distance squared weighting for the 6 nearest monitors within a 1 degree radius. Alternative standard combinations were put forward for annual standards ranging from 12-15 µg/m3 (1 µg/m3 intervals) and for 24-hour (98^{th} percentile) standards ranging from 20-65 µg/m3 (5 µg/m3 intervals). Estimates for a 24-hour 99^{th} percentile were calculated using the derived relationship between 98^{th} and 99^{th} percentile forms (rounding up to 5 µg/m3).

The analysis of continuous PM2.5 data (50°C Tapered Element Oscillating Microbalance (TEOM) method) from New Haven, CT uses data collected at State Street in New Haven, CT from October 1997 to December 2002. The 50°C TEOM method daily or subdaily data are subject to large errors because of a substantial loss of semi-volatile mass. Therefore PM2.5 levels are likely to be underestimated on winter days with high PM2.5 concentrations or during hours with the highest local mobile source influence. In general, data with highest temporal resolution (e.g., 1-hour data) have the greatest potential to underestimate PM2.5 relative to "FRM-like" levels.

Continuous PM2.5 data for the analysis of 24-hr and maximum subdaily-hr averages were obtained from Region 1, 2, and border state monitoring networks for 2001. The analysis considered a day's 24-hr average valid if 16 hourly values were reported. Rolling 3, 4 and 6-hr averages were calculated and the maximum average for each interval was tabulated for each day. Valid averages required 3 or 4 hrs for those averaging periods respectively, while a valid 6 hr average required at least 5 valid hourly values. Max 3-hr averages were associated with their corresponding 24-hr average. The 24-hr averages were sorted from lowest to highest.

The number of susceptible persons identified as potentially at elevated risk to PM living in counties with PM2.5 levels exceeding various annual / 24-hour standard combinations was calculated for age subgroups and persons with preexisting health conditions using 2000 U.S. Census age demographic and Centers for Disease Control and Prevention health survey disease prevalence data. Disease rates were multiplied by the number of persons in respective adult and child age groups estimated to be living in counties with PM2.5 levels exceeding PM2.5 standard combinations.

Age subgroup sizes were calculated from the 2000 U.S. Census. Pre-existing disease condition indicators were matched to available disease prevalence rates generated by recently published CDC health surveys. Adult (≥18 yrs) self-reported asthma rates (lifetime) were obtained from the 2002 Behavioral Risk Factor Surveillance System (BRFSS). The mean lifetime asthma prevalence rate for the 8 states in the study area was calculated from each state-level prevalence rate. Lifetime asthma was defined as an affirmative response to the question "Have you ever been told by a doctor (nurse or other health professional) that you have asthma?". Adult sinusitis rates (past 12 months) and chronic bronchitis rates were obtained from the 2000 U.S. Adult National Health Interview Survey. NHIS defines the Northeast U.S. as the 6 New England states, NJ, NY, and PA. Respondents were asked in separate questions whether they had been told by a doctor or other health professional in the past 12 months that they had sinusitis or bronchitis. Adult cardiac prevalence rates were acquired from the 2000 NHIS. In separate questions, respondents were asked if they had ever been told by a doctor or other health professional that they had hypertension (or high blood pressure); coronary heart disease; angina (or angina pectoris); heart attack (or myocardial infarction); any other heart condition or disease not already mentioned. Persons had to have been told on 2 or more different visits that they had hypertension, or high blood pressure, to be classified as hypertensive. Heart disease was defined to include coronary heart disease, angina pectoris, heart attack, or any other heart condition or disease. Adult diabetes prevalence rates (ever) were obtained from the 2001 BRFSS report. Diabetes was defined as an affirmative response to the question, "Have you ever been told by a doctor that you have diabetes?" Child (0-17 yrs) respiratory allergies (past 12 months) and asthma (ever) prevalence rates were acquired from the 2001 U.S. Children NHIS. Allergy rates were based on the following questions: "During the past 12 months, has [child's name] had any of the following conditions? Hay fever? Any kind of respiratory allergy?..." Asthma rates were based on the question "Has a doctor or other health professional ever told you that [child's name] has asthma?"

Analysis limitations

With respect to the study's use of monitoring data, the assessment followed EPA methods by assigning the highest annual or 24-hour design values as the design values for the entire county. Likewise, for those counties without monitors, the highest annual or 24-hour interpolated levels were used from counties with monitors. This method could result in an overestimation of the number of persons exposed to PM2.5 concentrations at the county-level. However, the study applied county-level population estimates to include all persons in the study region. EPA currently defines attainment/nonattainment areas by consolidated metropolitan statistical areas that aggregate counties. Application of a 3-year data set (2000-2002) incorporating a wide range of monitoring sites and concentration values allowed us to establish the relationship between various PM2.5 standard metrics. The inclusion of additional years to the analysis likely would not materially change this relationship, unless factors driving PM concentrations across the northeastern region were suddenly to change. Since 2002, this has not happened. Recognizing the difficulty in determining absolute population numbers or pollution levels, the study focused on establishing data structure and inherent relationships between the annual and 24-hour metric and the impact these standards and their relative stringency have on the level of public health.

A central limitation of the study was its inability to generate additive estimates of total susceptibility across the 8-state study region. The population as a whole is considered diverse in its susceptibility to inhaled pollutants and persons may be represented in multiple categories of susceptibility. The range of sensitivity among persons is uncertain, as variations in PM exposure, PM dose, and host-related factors can cause exposed people to be more susceptible.

The study did not quantify the potential for a varying profile of susceptibility to PM across spatial scales. CDC's NHIS findings were regional and included the 8-state study area and PA. The BRFSS survey provided prevalence rates by state, but only for adults. Regional and state resolution scales do not enable one to distinguish prevalence rates between, for example, urban and non-urban populations with respect to specific states or other geographic scales. Concerning the integration of disease prevalence rate data with PM2.5 design value estimates, the uniform application of CDC prevalence rate data to populations living in counties not meeting alternative PM2.5 standards assumes that CDC data for the region are representative of those counties.

Additionally, the study could have benefited by integrating data sets that encompassed categories of sensitivity or vulnerability relating to socioeconomic status (e.g., economically disadvantaged populations) and heightened exposure status (e.g., outdoor worker, child, athlete, other exercising adult and child, and commuter subgroups). A consideration of projected demographic shift and epidemiologic transitions likely would have augmented the import of study findings.

For more detailed explanation of methods or other questions relating to these analyses, please contact:

Philip Johnson, NESCAUM
pjohnson@nescaum.org
(617) 259-2075