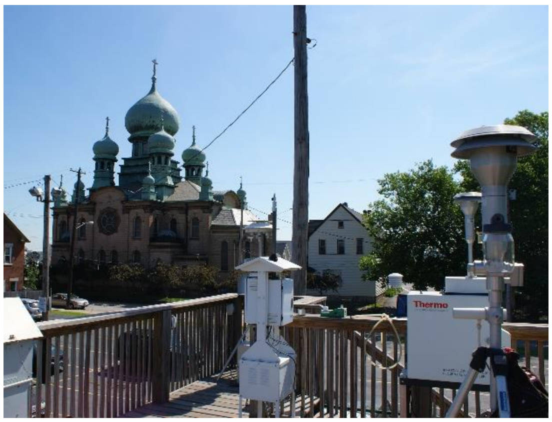
5-Year Monitoring Network Assessment for the LADCO States: IL, IN, OH, MI, MN, WI

2015 Final Report







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Executive Summary

As required by 40CFR Part 58.10(d), a regional assessment of air quality monitoring for criteria pollutants was performed to provide the state and local networks with information on (1) whether their networks still meet the monitoring objectives, (2) whether new sites are needed, (3) whether existing sites are no longer needed, and (4) whether new technologies are appropriate for incorporating into the network. The recommendations in the assessment are nonbinding and are intended to help inform the state and local agencies of the relative strengths and weaknesses of their networks.

Because the data analyses performed for this network assessment are potentially useful for many more purposes than this project, the state and local agencies chose to present the bulk of this assessment online. Two separate web tools were developed by the state workgroup for this assessment. The first, called NetAssess (https://ebailey78.shinyapps.io/NetAssessApp/), was a complete rewrite of the analytical tools that EPA produced for the prior 5-year assessment. The second tool is a data viewing application built on EPA's Geoplatform as a Story Map (http://epa.maps.arcgis.com/apps/MapJournal/?appid=75fbdd8408cb47f3921b976c57ecaa85). Each of the analyses performed as part of this assessment are presented as a layer that can be selected and viewed on the map. This assessment focused on ozone and PM2.5 because those are the criteria pollutants that present by far the greatest threat to public health in the region. Other pollutant monitoring is assessed more qualitatively and is not part of the site ranking procedure.

The state and local agencies in Region 5 currently operate over 338 criteria pollutant monitoring sites at a cost of over $20 million. Maps of the networks for each pollutant are available through the Story Map at the link above. The adequacy of current networks was assessed with a number of analyses, including area served, population served, removal bias, correlation analysis, exceedance probability, design value ranking, deviation from design value, unmonitored area analysis (in combination with gridded emission inventory analysis), length of record, number of parameters monitored, monitor shutdown criteria, and an overall ranking. In addition, a financial analysis of monitoring network costs and challenges associated with current funding levels and future expected monitoring needs was conducted.

Key findings are as follows:

1. Criteria pollutant monitoring networks are generally adequate to meet EPA's minimum criteria. Despite the overall adequacy of the networks, some shortfalls were identified. The networks are aging and most monitoring technology is significantly dated. Repair and maintenance costs are considerable. The proliferation of commercially available small sensors is promising, but federal reference methods for all of the criteria pollutants demand more precision and accuracy than the new sensors can currently deliver. Continuing research and development of new monitoring technology that meets FRM criteria is urgently needed to reduce the burden of maintaining aging equipment and bringing the public data that is easily accessible and of high quality.

2. Shutdowns of PM2.5 and ozone sites are very difficult if not impossible because of extremely stringent criteria set by EPA. This analysis identified only 1 of more than 200 ozone monitors that met those criteria, and only 10 of 124 PM2.5 monitors that met the criteria, all in the far northern part of the region. EPA should relax these requirements so states can shut down highly correlated monitors in dense urban networks where multiple monitors are measuring the same air mass and not providing unique information.

3. Defunding of some rural and low concentration PM2.5 speciation monitors jeopardizes important SIP tasks of model validation and characterization of upwind and background concentrations. The reliance on IMPROVE monitors to provide rural data is understandable, but IMPROVE also has funding shortfalls that make maintaining adequate geographic coverage more difficult. As concentrations decrease over time, the role of background concentrations relative to local emissions becomes both more critical to understand and more difficult to distinguish, reinforcing the need for such measurements.

4. The NO2 near-roadway sites have been difficult to establish and have high operating costs. Until the value and use of measurements so close to roadways is established, we suggest that Phase 3 implementation in smaller cities be postponed or eliminated. At the population-based NO2 sites, concentrations are well below the NAAQS and all monitoring is in urban areas. With the potential for a more restrictive ozone standard, some expansion to rural and upwind sites may be prudent, with a commensurate increase in EPA funding.

5. The SO2 network is focused on large sources, and the emissions density analysis shows that the distribution of sites provides excellent coverage in areas of high emissions. However, at this time it is not possible to account for the impact of the forthcoming SO2 data requirements rule and the possibility of additional SO2 monitoring as a result of that rulemaking.

Several new priorities and issues were also identified as part of this assessment. The expected new ozone standard will require greater efforts to control precursors in cities that have not previously had ozone concerns. The additional challenge of a reaching lower O3 concentrations across a broader geographic area will create a monitoring burden for PAMS or PAMS-like measurements, but also for background precursor measurements, especially NOx, in low concentration areas. Additional EPA funding will be required to meet this new monitoring burden.

As PM2.5 concentrations continue to respond to SO2 and NOx controls, the atmospheric chemistry that governs PM2.5 formation becomes more sensitive to ammonia (NH3). Increasing industrialization of farming operations and the resulting concentration of ammonia emissions means that there is a need for greater understanding of this PM2.5

precursor gas. There is a clear need for better ammonia characterization across the Midwest, including development of monitoring methods with good time resolution and sensitivity over a wide range of ambient concentrations. EPA should support research in this area.

All of the R5 states have fish consumption advisories based on mercury, yet there is no stable funding available for mercury measurement. In light of the recently implemented MATS rule and its requirement for mercury controls, a consistent network is needed to track trends and develop estimates of local contributions and long range transport.

Introduction

As required by 40CFR Part 58.10(d), a regional assessment of air quality monitoring for criteria pollutants was performed to provide the state and local networks with information on (1) whether their networks still meet the monitoring objectives, (2) whether new sites are needed, (3) whether existing sites are no longer needed, and (4) whether new technologies are appropriate for incorporating into the network. The assessment's recommendations are nonbinding and are intended to help inform the state and local agencies of the relative strengths and weaknesses of their networks.

Because the data for the networks is used for many more purposes than this 5-year assessment, the states chose to present the bulk of this assessment online. The flexibility of the web interface increases the usability of both the raw data and the results of the individual analyses. These improvements include the ability to zoom to an area of interest for ease of viewability. Users can also click on individual monitors and to bring up specific data for that monitor (monitor ID and location, design value, 10-year trends, demographics, rankings, etc.) This data is important in many contexts, not just this 5-year assessment, and we are pleased to make it widely available in an easy-to-use platform for state, local, and federal monitoring and policy staff as well as the general public.

Two separate web tools were developed by the state workgroup for this assessment. The first, called NetAssess (https://ebailey78.shinyapps.io/NetAssessApp/), was a complete rewrite of the analytical tools that EPA produced for the prior 5-year assessment. These older tools no longer worked due to software changes, and EPA was not able to provide resources for updating. The workgroup essentially started from scratch and rewrote the application, which consists of 4 distinct analyses described below. Because many state analysts have restricted ability to download executable files to their work computers, the app was designed as a tool that operates from a web browser with no need for the user to install software files or provide their own data. In addition, all the programming code (in R) is open source and freely available.

The second tool is a data viewing application built on EPA's Geoplatform as a Story Map (http://epa.maps.arcgis.com/apps/MapJournal/?appid=75fbdd8408cb47f3921b976c57ecaa85). Each of the analyses performed as part of this assessment are presented as a layer that can be selected and viewed on the map. Data for this tool are for the Region 5 states only. Users can view each of the criteria pollutant networks in their entirety or zoom to an area of interest. Popup boxes for each monitor provide location, site ids, design values, and other associated information. Additional layers (described further below) include nonattainment areas, metropolitan statistical areas, gridded emissions, analysis results, monitor rankings, and a link to environmental justice data.

This assessment focused on ozone and PM2.5 because those are the criteria pollutants that present by far the greatest threat to public health in the region. Other pollutant monitoring is assessed more qualitatively and is not part of the site ranking procedure.

Overview of Current Networks

The state and local agencies in Region 5 currently operate over 338 criteria pollutant monitoring sites at a cost of over $20 million. Maps of the networks for each pollutant are available at the following link: http://epa.maps.arcgis.com/apps/MapJournal/?appid=75fbdd8408cb47f3921b976c57ecaa85. Since the last 5-year assessment, the states have met a number of challenges, including establishing NCORE sites; establishing new lead monitoring sites, establishing near-road NO2 and CO sites; and continuing to assess the performance of and transition to continuous PM2.5 monitors where appropriate. A current challenge is meeting new monitoring/modeling requirements for SO2.

The adequacy of current networks was assessed with a number of analyses. EPA's monitoring regulations (40 CFR 58.10, App. D) identify three general monitoring objectives: (a) provide data to the public in a timely manner, (b) support compliance with NAAQS and control strategy development, and (c) support air pollution research studies. For each objective, several analyses provide a technical basis on which to determine adequacy. These are summarized in Table 1 below and briefly discussed individually; detailed results of each analysis are available via the links provided.

Table 1 Crosscheck between monitoring objectives and data analyses

Objective	Subobjective	Analysis
Provide data to public in timely manner	Public reporting, assuring adequate geographic and population coverage	Spatial analyses: Area served, population served, removal bias, correlation analysis
Support compliance with NAAQS	Attainment analysis	Concentration-based analyses: Design value ranking, deviation from design values, unmonitored area analysis
Support control strategy development	Characterize regional concentrations, track progress	Spatial analyses (above), length of record ranking, inventory analysis
Support air pollution research		Emission inventory analysis, number of parameters analysis

Tools and Analyses

NetAssess

The NetAssess suite of tools (access at https://ebailey78.shinyapps.io/NetAssessApp/) provides online results for 4 different analyses: area and population served, correlations, removal bias, and exceedance probability. Its spatial extent is the continental US, and it provides analysis based on 2011-2014 ozone and PM2.5 data that meet EPA's minimum completeness requirements. Data are presented via an interactive map, so that users can select an area of interest (city, state, region), perform the analysis, and download results in a spreadsheet format. In addition, popup boxes deliver additional monitor-specific data based on the analyses. Results from the first 3 analyses are incorporated into the Geoplatform story maps and the overall rankings for ozone and PM2.5 monitors.

Area and Population Served. The area served tool uses a spatial analysis technique known as Voronoi or Thiessen polygons to show the area represented by a monitoring site. The shape and size of each polygon is dependent on the proximity of the nearest neighbors to a particular site. All points within a polygon are closer to the monitor in that polygon than to any other monitor. Once the polygons are calculated, data from the 2010 decennial census are used to find the census tract centroids within each polygon. The population represented by the polygon is calculated by summing the populations of these census tracts.

Clicking on a polygon displays an information popup box that lists both the area served, in square miles and square kilometers, and the population within the polygon. In addition, the popup box displays charts of the population breakdown by age and sex. The charts can be enlarged by clicking on them. The area and population data for the selected polygons can be downloaded as a comma-delimited file (.csv). Sample graphical output is shown in Fig. 1.

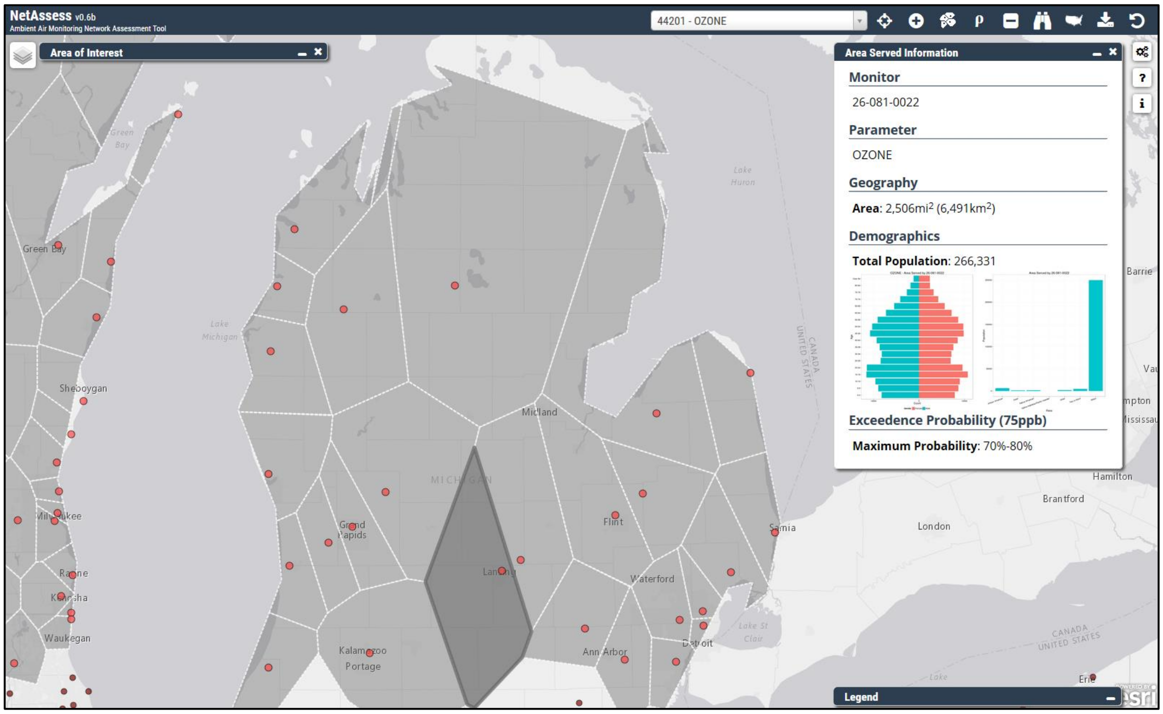

Figure 1. Example Output from the NetAssess Area and Population Served Tool

Correlation Matrices. The Correlation Matrix tool calculates and displays the correlation, relative difference, and distance between pairs of sites within a user selected set of air monitoring sites. Within the NetAssess App the Correlation Matrix Tool generates a graphical display and a downloadable CSV file which summarize the results for each selected site pair. The purpose of this tool is to provide a means of determining possible redundant sites that could be removed. Possible redundant sites would exhibit fairly high correlations consistently across all of their pairings and would have low average relative difference despite the distance. Usually, it is expected that correlation between sites will decrease as distance increases. However, for a regional air pollutant such as ozone, sites in the same air shed can have very similar concentrations and be highly correlated. More unique sites would exhibit the opposite characteristics. They would not be very well correlated with other sites and their relative difference would be higher than other site to site pairs. A sample correlation matrix is shown in Fig. 2.

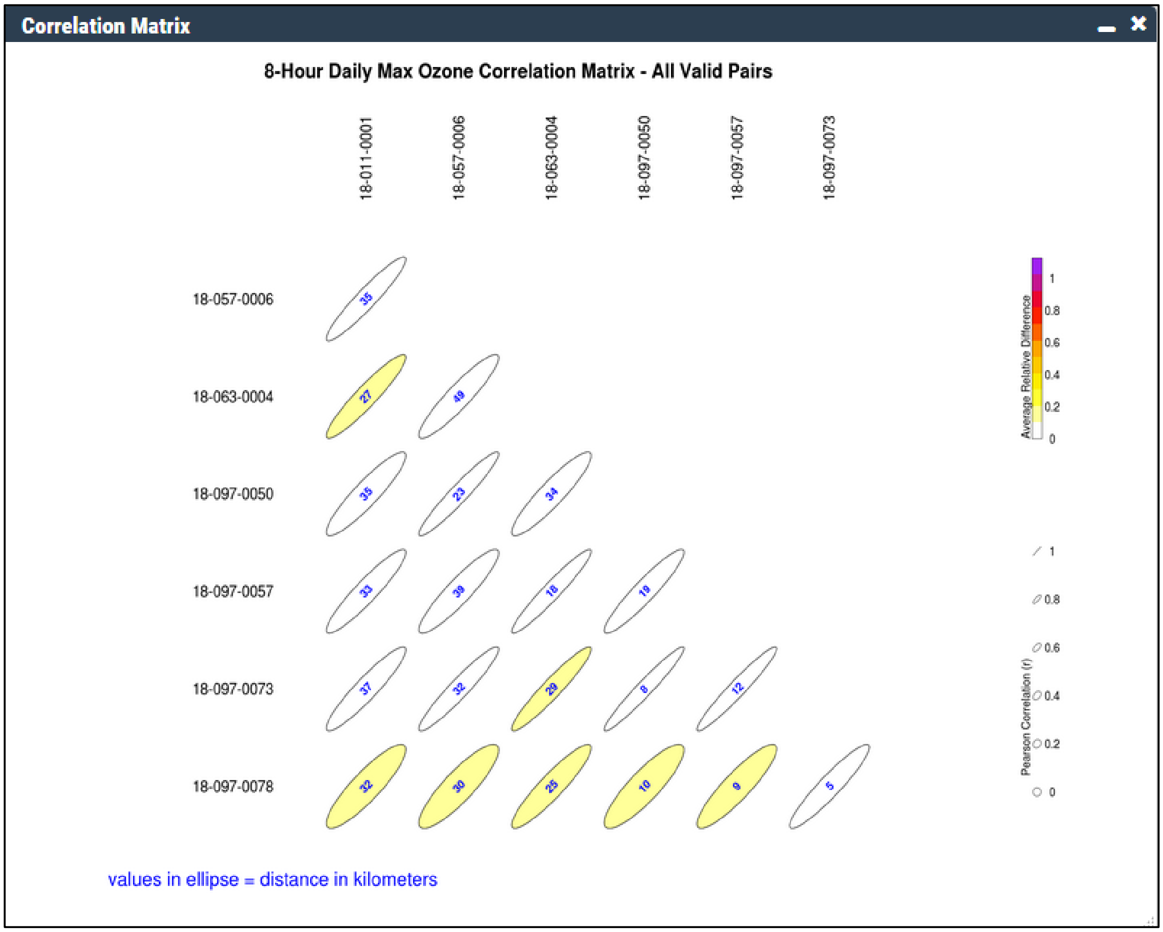

Figure 2. Example Output from the NetAssess Correlation Tool

Removal Bias. The removal bias tool is meant to aid in determining redundant sites. The bias estimation uses the nearest neighbors to each site to estimate the concentration at the location of the site if the site had never existed. This is done using the Voronoi Neighborhood Averaging algorithm with inverse distance squared weighting. The squared distance allows for higher weighting on concentrations at sites located closer to the site being examined. The bias was calculated for each day at each site by taking the difference between the predicted value from the interpolation and the measured concentration. A positive average bias would mean that if the site being examined was removed, the neighboring sites would indicate that the estimated concentration would be larger than the measured concentration. Likewise, a negative average bias would suggest that the estimated concentration at the location of the site is smaller than the actual measured concentration. Sample output from the removal bias tool is shown in Fig. 3.

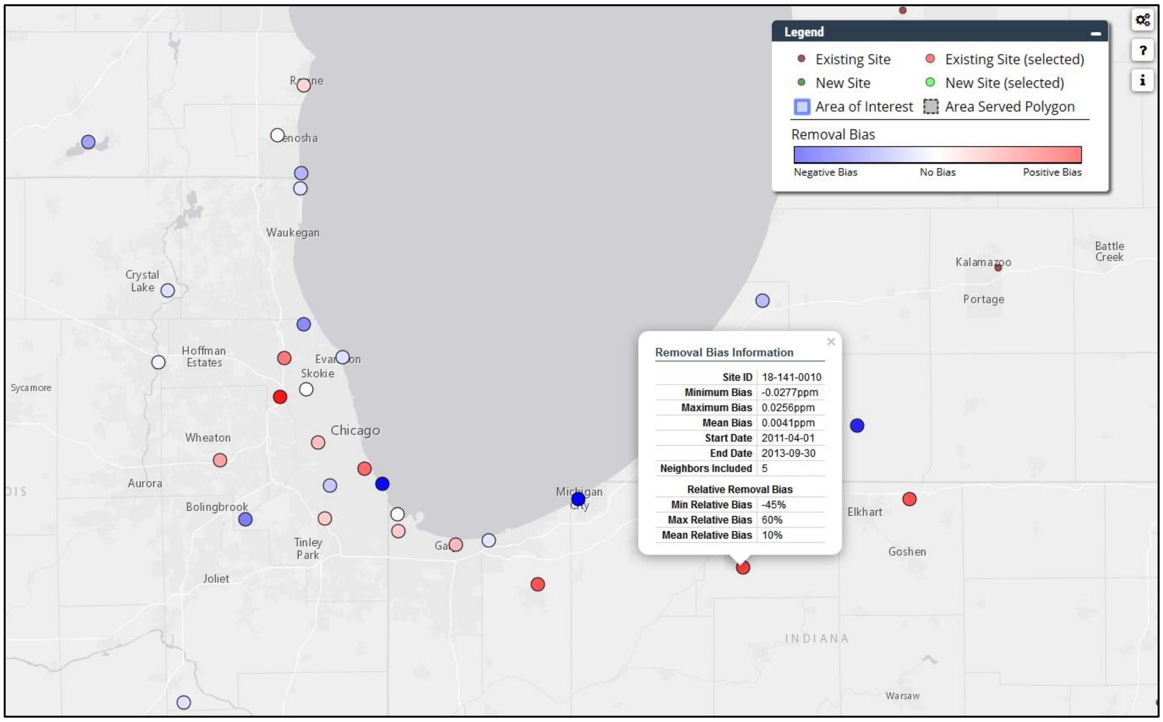

Figure 3. Example Output from NetAssess Removal Bias Tool

Exceedence Probabilities. One objective of the network assessment is to determine if new sites are needed. In order to make that decision, it is helpful to have some estimation of the extreme pollution levels in areas where no monitors currently exist. NetAssess provides ozone and PM2.5 maps of the contiguous US that can be used to make spatial comparisons regarding the probability of daily values exceeding a certain threshold (see Fig. 4 for an example).

These maps do not show the probability of violating the National Ambient Air Quality Standards (NAAQS). They provide information about the spatial distribution of the highest daily values for a pollutant (not, for example, the probability of the 4th highest daily 8-hour ozone maximum exceeding a threshold).

These maps are intended to be used as a spatial comparison and not for probability estimates for a single geographic point or area. The probability estimates alone should not be used to justify a new monitor. The maps should be used in conjunction with existing monitoring data. If a monitor has historically measured high values, then the probability map gives an indication of areas where you would expect to observe similar extreme values. This information, along with demographic and emissions data, could be used in a weight of evidence approach for proposing new monitor locations.

The surface probability maps were created by using EPA/CDC downscaler data. Downscaler data are daily estimates of ground level ozone and $PM_{2.5}$ for every census tract in the continental US. These are statistical estimates from “fusing” photochemical modeling data and ambient monitoring data using Bayesian space-time methods. For more details on how the data were generated, see the meta data document on the EPA website.

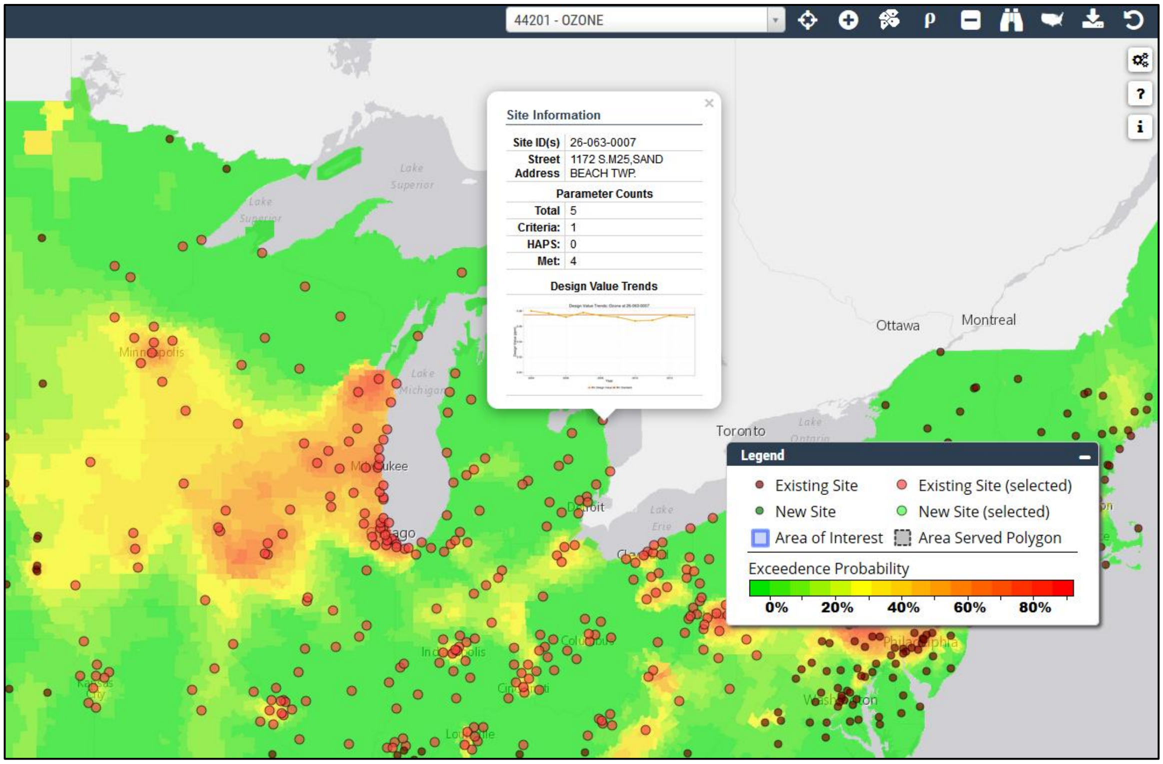

Figure 4. Example Output from NetAssess Exceedance Probability Tool

GeoPlatform Story Maps

The Geoplatform Story Maps can be accessed at http://epa.maps.arcgis.com/apps/MapJournal/?appid=75fbdd8408cb47f3921b976c57ecaa85. The maps (described further below) include nonattainment areas for all criteria pollutants; gridded emissions for SO2, NOx, VOCs, and primary PM2.5; design values for all criteria pollutants; ozone monitor rankings for 7 individual criteria (area served, population served, number of parameters monitored, design value, number of years monitored, correlation with other sites, and removal bias) plus an overall ranking; PM2.5 monitor rankings for the same set of criteria; and a link to EPA's new Environmental Justice tool, EJScreen.

Nonattainment Areas. Maps of current nonattainment areas for each criteria pollutant make up the first 'chapter' of the Story Map and provide background information for monitor siting. Figure 5 shows ozone nonattainment areas as an example.

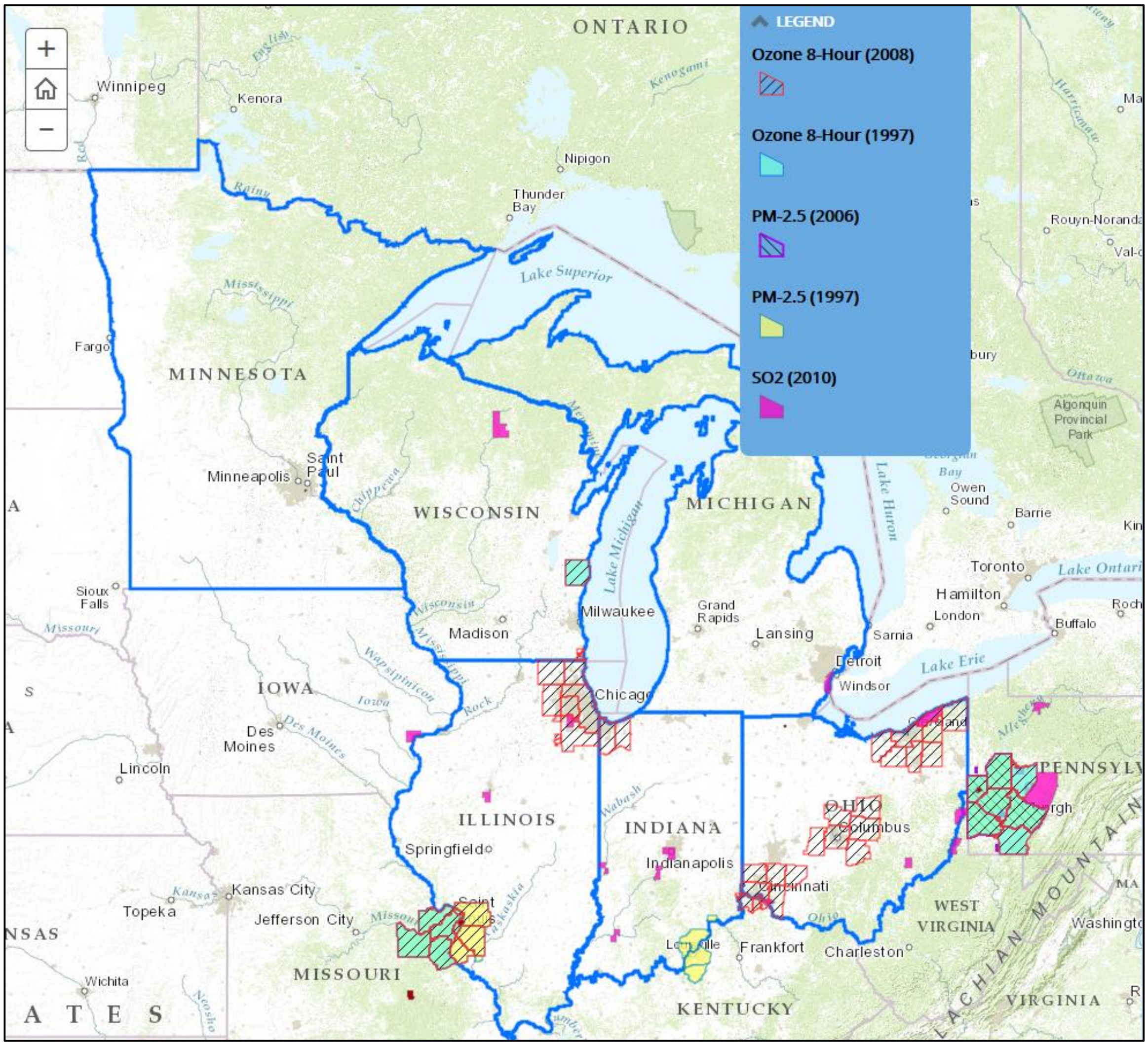

Figure 5. Example of Nonattainment Map Layers

2011-2013 Design Values. Maps of design values for each criteria pollutant are provided in this next chapter of the Story Map application. The color scheme for each of the design value plots depicts concentrations as a percent of the relevant NAAQS, so red always depicts sites that have design values greater than the NAAQS, yellow depicts sites greater than 90% but still below the NAAQS, etc. Figure 6 shows ozone design values as an example.

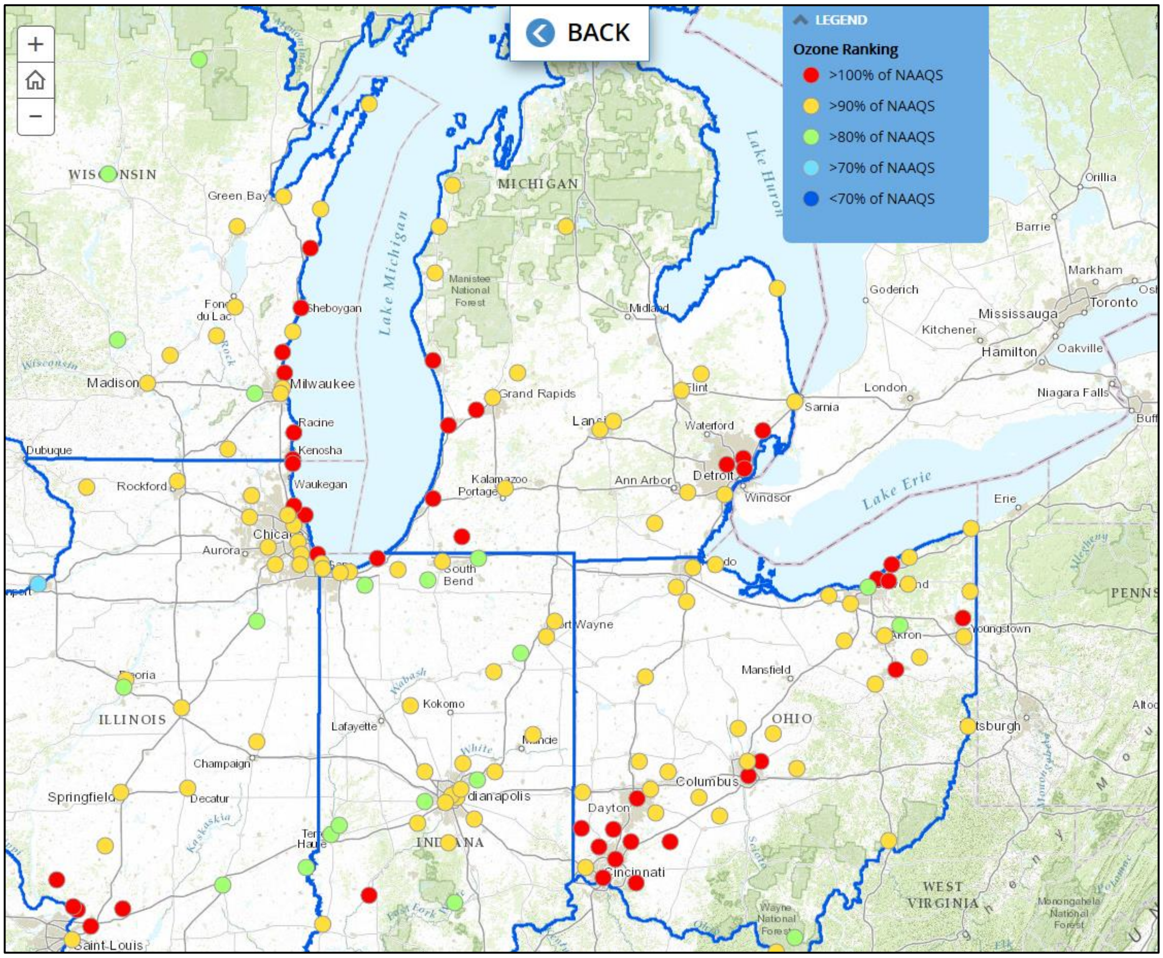

Figure 6. Example of Design Value Maps Showing Ozone Design Values as % of NAAQS

Ozone**.** More than 40 monitoring sites currently exceed the NAAQS in Region 5. The expected revision of the ozone standard at the end of 2015 to a lower level than the current .075 ppm will likely lead to additional monitors that exceed the standard and possibly additional or larger nonattainment areas. For example, the green, yellow, and red dots together represent monitors that exceed 80% of the current NAAQS, which is equivalent to a level of 0.060 ppm, at the lower end of the range of levels recommended by EPA's advisors.

PM2.5. In general, PM2.5 concentrations increase moving from the northwestern parts of the region to the southeastern parts of the region. Climatology and proximity to emission sources play a role in this geographic pattern. With respect to the annual standard, a few sites in urban areas on the southern and eastern edges of the region are currently out of attainment, but most of the region is meeting the ambient air quality standard for PM2.5. All sites in the region are currently attaining the daily standard. Data for Illinois is missing due to multiple years of invalid data resulting from quality assurance issues that occurred at the lab contracted to weigh sample filters.

Lead. Ambient lead levels have declined significantly in recent years to levels well below the standard, so most lead monitoring in the region is now focused on particular industrial sources. A few monitors fail to attain the NAAQS in Illinois and Indiana. Illinois has addressed those sources through rulemaking and monitors are expected to come into attainment soon.

NO2. The NO2 NAAQS has both an annual and a 1-hour component. Ambient concentrations of NO2 in general are far below the level of the annual standard (53 ppb) and have been for years. In 2010, EPA promulgated a 1-hour NAAQS for NO2 in addition to the annual standard. Because NO2 concentrations tend to be higher near roadways, a new monitoring requirement for near-roadway NO2 sites was also instituted at the same time as the 1-hour standard. Although the near-roadway network is not yet fully implemented, data currently show attainment with the 1-hour standard everywhere in the region.

PM10. There are no PM10 nonattainment areas in the 6-state region, and most monitors are measuring less than 50% of the standard. A few monitors have 3 year averages over the standard.

CO. All monitors in the region have design values less than 55% of both the 1-hour and 8-hour NAAQS.

SO2. Since June 2010 there has been a primary SO2 NAAQS that is a three year average of the 99th percentile values of the highest daily 1-Hour concentration. That average must be 75 ppb or lower. The primary standard is also used as the secondary standard as well as retaining the original secondary standards of 0.5 ppm as a three hour average. There is also a requirement that the number and location of monitors be based on the Population Weighted Emissions Inventory (PWEI) in each Core Based Statistical Area (CBSA) and at NCore sites. In Region 5, each state except Minnesota has at least one monitor currently exceeding the NAAQS and at least one area designated nonattainment.

Gridded emissions. Emissions from the LADCO 2011 inventory are plotted on the national 12-kilometer grid used for photochemical modeling, along with monitor locations. The data are log-transformed for display, but clicking on an individual grid cell will produce a popup box with the actual emissions in units of tons/year. These emissions density maps can help determine whether there are areas of higher emissions that might benefit from additional monitoring, or areas upwind of high concentrations that should be monitored for better characterization of urban-rural differences or adequate spatial characterization. More information on development of the emission inventory data can be found here: http://www.epa.gov/ttn/chief/trends/index.html. By comparing monitor locations with the distribution of emissions, it is clear that the networks for PM2.5 and SO2 have excellent coverage of the highest emission areas (see Fig. 7, for example). The VOC and NOx networks are much less dense. Because ambient NO2 concentrations are low, the current network is adequate for NAAQS determination, pending results from the new near-road networks. Nevertheless, because NO2 is such an important precursor to ozone, rural measurements are needed for photochemical model validation and the current networks are too sparse to provide sufficient measurements for that objective.

PM2.5: The PM2.5 emissions are only those directly emitted from sources. Most PM2.5 is formed as a secondary pollutant from the reaction of its precursor gases, SO2, NOx, and NH3, so only a fraction of all atmospheric PM2.5 is represented. Major sources of primary PM2.5 are combustion processes, including fossil fuel combustion, prescribed burning, and wildfires.

SO2: Sulfur dioxide (SO2) is a criteria pollutant and PM2.5 precursor. Primary sources are coal-fired utility and industrial boilers. Shipping is another significant source.

Figure 7. Example Map of SO2 Emissions Density and Monitor Locations

VOC: Volatile organic compounds (VOCs) are not criteria pollutants, but are important precursors to ozone formation and play a small role in PM2.5 formation as well. In addition to anthropogenic sources such as gasoline and solvent evaporation, biogenic sources (plants) are a major part of the inventory. This plot shows only anthropogenic emissions. A few locations collect VOC measurements and these are indicated as red dots.

NO2: Nitrogen dioxide (NO2) is a criteria pollutant and a precursor of both PM2.5 and ozone. Most nitrogen dioxide is emitted as nitric oxide (NO) but quickly transforms in the atmosphere to NO2. It then can react with ammonia to form particulate ammonium nitrate, which is a major constituent of PM2.5, especially in the winter. During the summer, NO2 plays a major role in the complex chemistry of ozone formation. Primary sources of NO2 are high-temperature combustion processes such as automobile and truck engines and coal-fired boilers. New monitoring regulations require states to establish roadway monitoring sites in major urban areas (see locations of NO2 monitors on the 2011-13 Design Values layer). The current NO2 network shows that all monitors attain the National Ambient Air Quality Standard. However, even at the current low concentrations, NO2 can contribute significantly to both PM2.5 and ozone formation. Thus continued measurements in both rural and urban areas are needed to validate photochemical modeling and assure that efforts to control all three pollutants are successful.

Ozone and PM2.5 Monitor Rankings. Ozone and PM2.5 sites were ranked on the basis of 7 criteria: population served, area served, number of parameters monitored, design value, number of years monitored, correlation with other sites, and removal bias. Absolute values for each of the criteria were converted to ranks from 0 to 4 (quintiles), with 0 the lowest rank and 4 the highest rank. The 7 ranks were then averaged for an overall ranking. Each criteria ranking as well as the overall rank is plotted on a separate map. Raw data for this analysis, along with all of the resulting ranks, are available at: http://www.ladco.org/reports/general/Regional_Network_Assessment/15_Regional_Network_Assessment.html

Population and Area Served Ranks. Ranks for population and area served by each monitor were developed from output of the NetAssess tool (https://ebailey78.shinyapps.io/NetAssessApp/). It uses a spatial analysis technique known as Voronoi or Thiessen polygons to show the area represented by a monitoring site. The shape and size of each polygon is dependent on the proximity of the nearest neighbors to a particular site. All points within a polygon are closer to the monitor in that polygon than to any other monitor. Once the polygons are calculated, the area encompassed by each is calculated. In addition, the population residing within the polygon can be determined from US Census data, as well as associated demographic data distributions by gender, age, and race. Ranks were assigned from 0 to 4, with 0 for monitors with the least population (lowest 20%) and 4 to monitors with the most population (highest 20%). See Fig. 8 for an example of this ranked analysis.

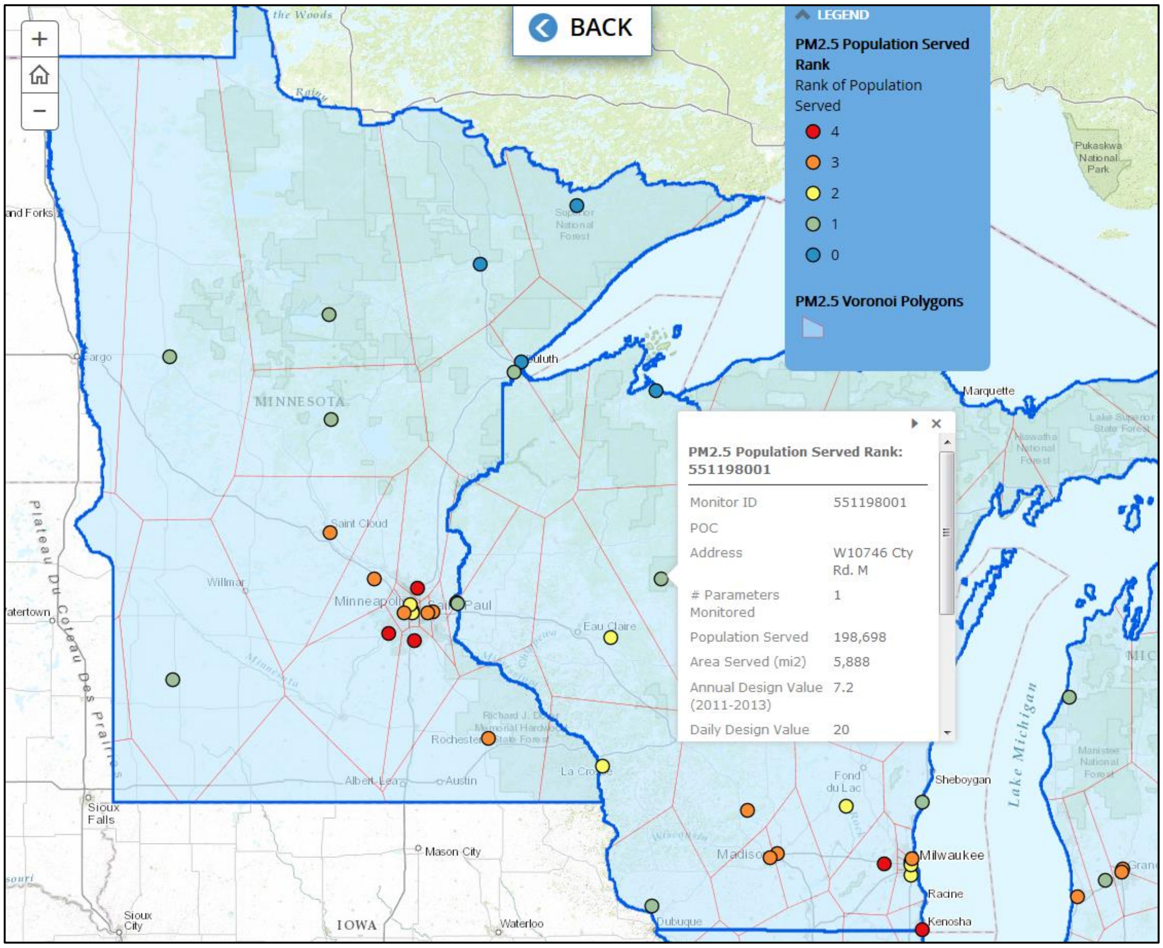

Fig. 8 Example Map of PM2.5 Area Served Rankings, Voronoi Polygons, and Data PopUp Box

Number of Parameters Monitored. Maintaining a monitoring site requires a considerable investment of staff time and operating costs, so it is often advantageous to maximize the number of parameters measured at each site and minimize the number of sites collecting just one or two parameters. Of course, siting criteria for each pollutant and monitoring objectives must be considered as well. In this analysis, sites are ranked from 0 to 4 by the number of pollutants that are measured, with 0 assigned to sites measuring the fewest unique pollutants and 4 to sites that have the most unique pollutants. Figure 9 shows data for this analysis as presented in the Story Map.

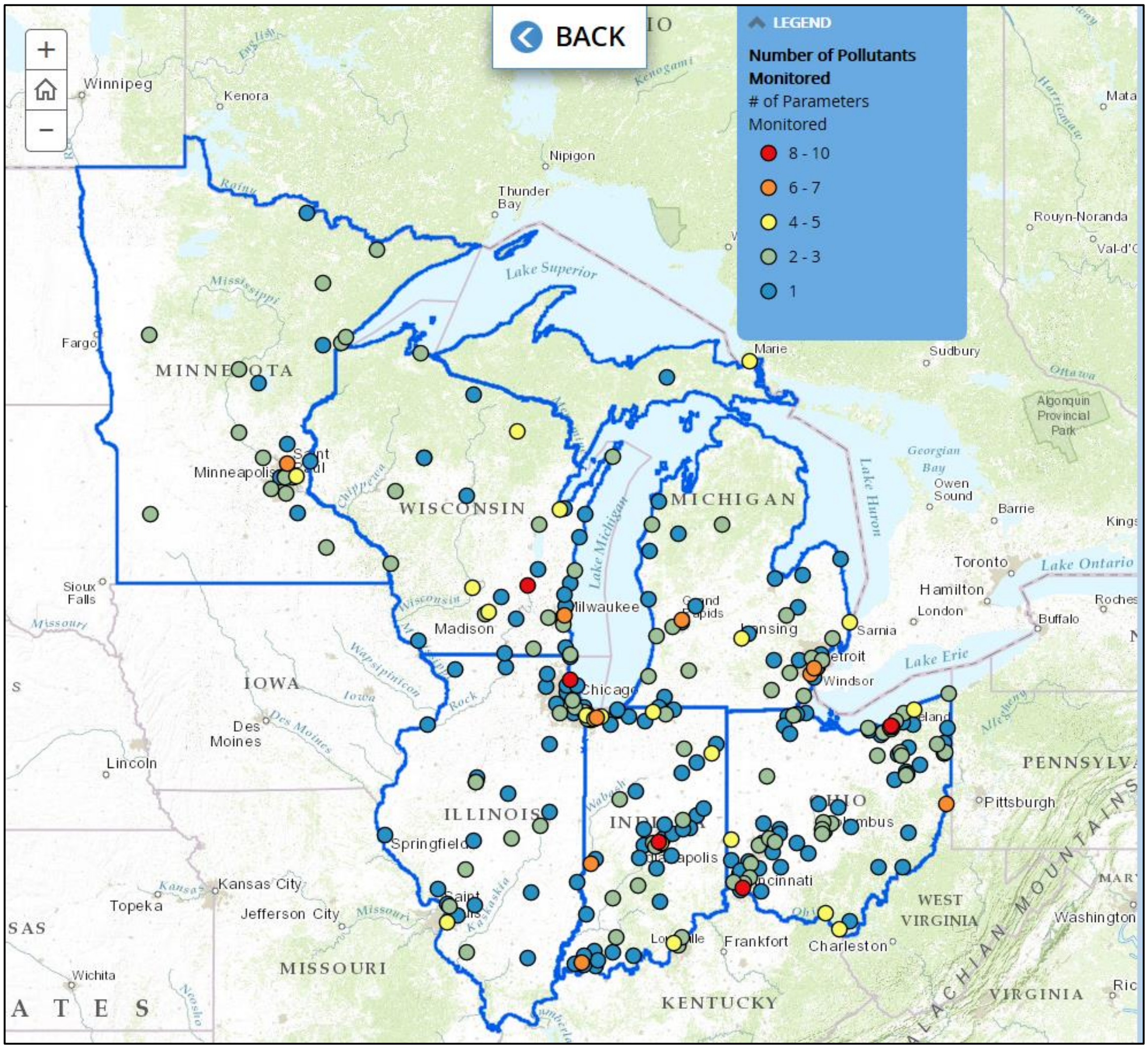

Figure 9. Number of Parameters Monitored at PM and Ozone Sites

Removal Bias Rank. An examination of removal bias is helpful in determining redundant sites. This analysis was performed with output from the NetAssess tool (https://ebailey78.shinyapps.io/NetAssessApp/). The bias estimation uses the nearest neighbors to each site to estimate the concentration at the location of the site if the site had never existed. This is done using the Voronoi Neighborhood Averaging algorithm with inverse distance squared weighting. The squared distance allows for higher weighting on concentrations at sites located closer to the site being examined. The bias was calculated for each day at each site by taking the difference between the predicted value from the interpolation and the actual measured concentration. A positive average bias indicates that if the site being examined was removed, the concentration estimated from neighboring sites would be larger than the measured concentration. Likewise, a negative average bias would suggest that the estimated concentration at the location of the site is smaller than the actual measured concentration. Sites are ranked by the absolute value of the average bias, since both underestimates and overestimates of concentration would be undesirable. Ranks are assigned by decile, with low bias given the highest rank of 4 and high bias given the lowest rank of 0. Fig. 3 presents the removal bias data before ranking.

Correlation Rank. Monitors that are closely correlated are generally believed to be sampling from the same air mass and provide less unique information than less correlated monitors. Monitors with very high correlations might be considered redundant and possible candidates for shutdown. Pearson correlations were calculated for all valid monitor pairs and the highest pairwise correlations for all monitors were then ranked by decile from 0 to 4, with highest correlations receiving low ranks and lowest correlations receiving high ranks. Figure 10 shows PM2.5 monitors ranked by correlations.

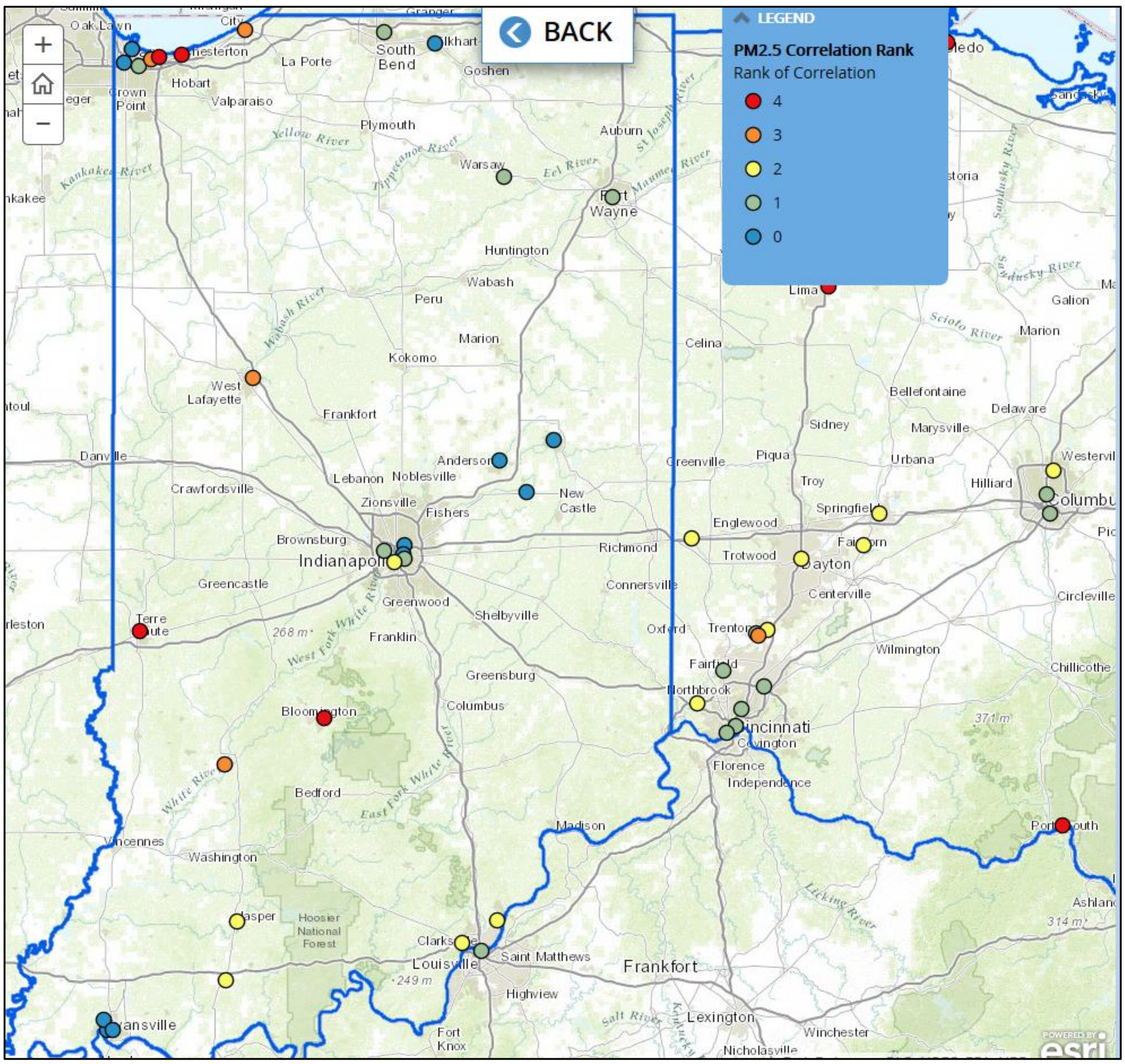

Figure 10. PM2.5 Monitors Ranked by Correlation

Years Monitored Rank. Sites with long monitoring records are extremely valuable for trends analysis and to track progress in air quality improvements. Sites with many years of data score high in this analysis.

2011-2013 Design Value Rank. This analysis ranks ozone and PM2.5 monitoring sites on the basis of their measured concentrations, as summarized by the 3-year design value from 2011-2013. Monitoring sites with high concentrations are clearly important because they reflect higher risks to public health from ozone exposure. Ozone and PM2.5 concentrations have been trending down over the last 15 years, but nonattainment areas persist in most states. A new, lower ozone NAAQS is expected in October 2015.

Overall Mean Rank. Results from these 7 individual analyses (8 for PM2.5 because the annual and daily design values were both included in the ranking) were combined into an overall assessment of the ozone and PM2.5 networks. A composite score was calculated by averaging the ranked scores for each monitor for the 7 analyses above. Each analysis was given equal weight, although states and other users may prefer to assign different weights to different analyses. Fig. 11 shows an example of the overall rankings from the Story Map. The raw data is available for those interested at http://www.ladco.org/reports/general/Regional_Network_Assessment/15_Regional_Network_Assessment.html

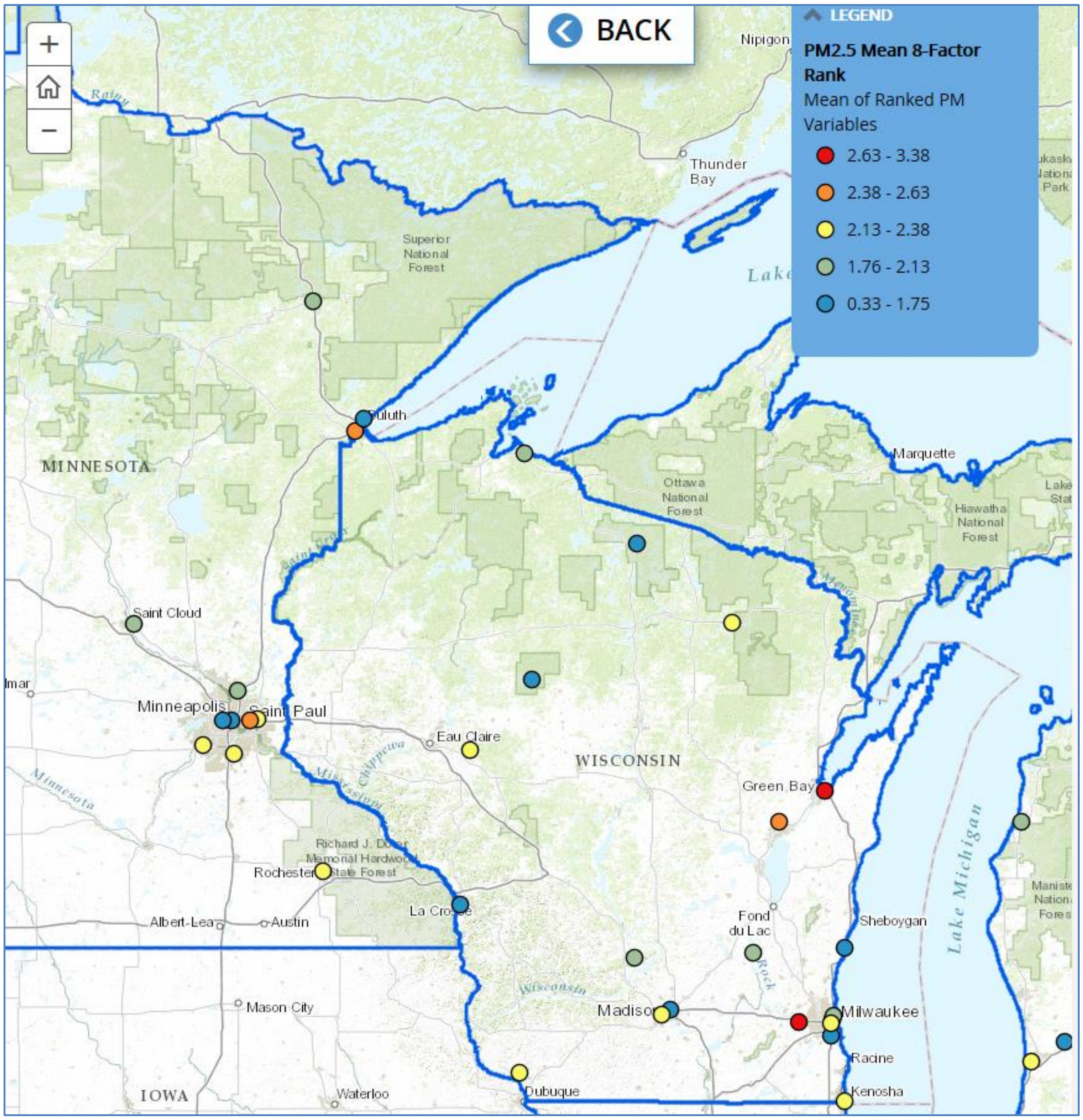

Figure 11. Example of Overall Rankings of PM2.5 Monitors

No ranking can completely capture the nuances of monitor siting and some aspects remain unquantifiable. For example, scores for area served, which ranks monitors higher for greater areas, will naturally tend to value rural monitors most highly, because the rural network is sparse and each monitor is intended to represent a large geographic area. In contrast, the scores for population served tend to value urban monitors more highly, because they are sited in areas of greatest population density. To some extent, these two scores will cancel each other, although they are not perfect inverses. Weighting one or the other of these in particular may have a significant effect on the composite score. Rural monitors in general tend to be undervalued in this analysis because they also tend to be lower concentration monitors. Despite their low concentrations, these monitors are particularly important for model validation, precisely because they provide information for the spaces between urban areas and allow us to better characterize air upwind and downwind. This analysis does not propose any specific monitors for shutdowns, but only suggests potential candidates that might be examined more closely if site closures are necessary.

Because EPA has specific criteria for shutting down monitors, both the ozone and PM2.5 networks were examined to see if monitors identified in this analysis as having lower ranks were eligible for shutdown. Only one ozone monitor (of more than 200), and 10 PM2.5 monitors (of 124) met EPA's shutdown the criteria as described in 48 CFR 58.14(c). The monitors are listed in Table 2. Of the four criteria that a monitor must meet, one in particular is extremely stringent. It requires the probability that the monitor will exceed 80% of the applicable NAAQS to be less than 10%, based on concentrations, trends, and variability in the past. In actual practice, this means that despite showing very high correlations among monitors and clear redundancy, it is not possible to meet this criteria except in areas of extreme low concentrations. Note that the purpose of this analysis is NOT to recommend these particular sites for shutdown. Rather, it demonstrates the extreme stringency of the shutdown criteria and supports the development of more flexible criteria that would allow for closures of sites that are clearly sampling the same air mass as demonstrated by high correlations and similar statistical measures.

Table 2. Monitors Eligible for Shut Down

Site	CBSA	Latitude	Longitude	2013 PM2.5 Annual Design Value	2013PM2.5 24-hour Design Value
260050003	Allegan, MI	42.77	-86.15	8.3	22
260170014	Bay City, MI	43.57	-83.89	7.6	20
260490021	Flint, MI	43.04	-83.67	8	20
261010922	Manistee, MI	44.31	-86.24	6.7	18
261130001	Cadillac, MI	44.31	-84.89	5.9	17
271377001	Virginia, MN	47.52	-92.54	6.1	16
271377550	Duluth, MN	46.82	-92.09	5.7	18
271453052	St. Cloud, MN	45.55	-94.13	7.9	22
550030010	Ashland, WI	46.60	-90.66	5.1	17
550410007	Forest County, WI	45.56	-88.81	5.1	19
The Ashland, WI, site (550030010) is the only ozone monitor eligible for shutdown.					

Financial Analysis: Revenue and Operational Costs

Revenue received by each state to operate their monitoring networks is given in Table 3 below. All states in either or both FY 2013 and 2014 received or had funding to implement several Near Road monitoring sites based on the Nitrogen Dioxide rule promulgated in 2010. The monies for that effort allocated by US EPA, $200,000, is not reflected in the above chart. These monies are a one-time grant (separate Section 103) to be used for site set-up including equipment purchases.

Table 3. Funding Revenue for Ambient Air Monitoring Networks

	FY2013				FY2014			
	Sec 105	Sec 103	Other*	Total	Sec 105	Sec 103	Other*	Total
	10/1/2012 – 9/30/2013	4/1/2013-3/31/2014		**FY2013**				**FY2014**
IL	*$2,018,764*	$987,597		$3,006,361	$2,021,937	$1,043,635		$3,065,572
IN	$2,743,944	$1,199,919	$919,471	$4,863,334	$2,728,524	$1,237,649	$931,575	$4,897,748
MI	$2,750,000	$1,615,716	$155,000	$4,520,716	$2,750,000	$2,278,788	$180,000	$5,208,788
MN	*$740,500*	$644,421	$496,600	$1,880,921	$750,389	$662,347	$499,000	$1,911,736
OH	*$1,802,168*	$1,987,841		$3,790,009	$1,816,420	$2,003,364		$3,819,784
WI	$1,466,317	$828,982	$140,827	$2,436,126	$1,455,888	$803,842	$125,483	$2,385,213
R5 Total	$11,521,693	$7,264,476	$1,711,298	$20,497,467	$11,523,158	$8,029,625	$1,736,058	$21,288,841

***Other** includes funding for state air toxics program, industry revenue for site operations, and other monies received to operate sites with a states monitoring network.
Numbers in italics are estimates.

Table 4 presents capital and operating costs, by monitor type. These costs were determined from those submitted by several monitoring organizations throughout the region. Because the operational costs vary throughout the region the highest operational costs are presented. Factors affecting the differences in operational costs include salary structures and benefit packages for monitoring personnel, location of monitoring site(s), land or space leases, age of equipment, and contractor costs for site set-up and relocation. Aging equipment normally requires more troubleshooting, repair and calibration which involve increased staff time. Additional staff time costs include data review and analysis. PM2.5 sampling: FRM, FEM and continuous PM2.5 all require increased data review to determine if/how operational parameters affect the validity of the data.

Table 4. Monitor Capital, Installation, and Annual Operating Costs, by Pollutant

	Capital Cost Per Site	Relocation or Installation Cost Per Site	Annual Operating Cost Per Site
Ozone	$70,000	$22,000	$22,000
Sulfur Dioxide	$80,000	$22,000	$37,500
PM10	$15,000	$7,000	$25,000
Carbon Monoxide	$70,000	$22,000	$25,000
Nitrogen Dioxide	$80,000	$22,000	$25,000
Lead	$7,000	$11,000	$35,000
PM2.5	$40,000	$15,000	$15,000
NCore	$110,00	$35,000	$265,000
Near Road	$135,000	$25,000	$125,000

Future Costs

If the ozone NAAQS becomes final as proposed, PAMS monitoring will be required at NCore sites in ozone nonattainment areas. US EPA estimates it will cost $150,000/site annually for operational costs with initial equipment costs of $700,00/site for a complete suite of instrumentation. The biggest challenges these sites present to the monitoring staff are learning to operate the equipment and interpret the data.

For areas that may use the enhanced ozone monitoring approach, equipment costs will be significantly less. However, they will still require significant staff time to adequately review and interpret the data.

These additions come without reductions in other areas. This will place an increased burden on staff who have been doing more with less with the goal of producing defensible data. The data are used for many purposes with the main goal of compliance with the National Ambient Air Quality Standards.

Some relief may be seen with shut down of a number of coal fired power plants within or near our regional borders. These closures, combined with a switch from coal fired boilers to gas fired boilers, are expected to result lower PM2.5 concentrations. However, Part 58 states that in order to disinvest a monitor, that monitor must have less than a 10% probability that the concentration will be within 80% of the NAAQS, so decreases in concentrations must be great enough to meet this stringent criteria. Until then, the intermittent samplers are aging and labor intensive, and the parts needed to perform repairs are costly. While there are numerous advantages to operating continuous PM2.5 analyzers, parts are expensive and the volume of data produced is far greater, which means data review requires more time and effort. Routine annual preventative maintenance is another cost that is necessary in order to maintain the reliable performance of the analyzers.

Additionally, the continuous PM2.5 analyzers still have comparability issues with the FRM even though monitoring organizations are working to bring operations of both into a better agreement with one another. To aid in the reduction of cost to operate PM2.5 FRMs, it will be prudent to work with US EPA to remove some of the higher correlating monitors and/or reduce the sampling frequencies. This will save on the wear of the FRMs, potential trips to the monitoring sites, and still permit protection of public health.

Conclusions

This section summarizes key findings of the data analyses and provides recommendations for changes that would improve the state monitoring networks and provide needed data from a regional perspective. An important aspect of synthesizing the analytical results is that they must be viewed holistically and with the understanding that no analysis stands alone. In addition, there are numerous aspects of the network that states and EPA must consider when making decisions about changes, and many cannot be quantified. Of course, implementation of any changes is subject to funding availability and EPA approval.

Overall adequacy of the networks: This analysis finds the criteria pollutant monitoring networks to be generally adequate in the sense of meeting EPA's minimum criteria. One exception to this is the Illinois PM2.5 network, which experienced significant quality control issues for much of 2012-2014 due to problems found at the lab contracted to weigh sample filters, and as a result had invalid data for a significant portion of the period that was reviewed for this analysis. This loss of data prevented a comprehensive analysis of the Illinois network. However, those issues have been resolved and are not expected to recur.

Despite the overall adequacy of the networks, some shortfalls were identified. The networks are aging and most monitoring technology is significantly dated. For example, despite the approval of continuous FEMs for PM2.5, most states have had difficulty making them perform well enough to feel comfortable replacing the gravimetric FRMs. Continuous instruments are needed to provide real-time information for the public, so both technologies are deployed at many sites. This duplication requires resources that could be saved if continuous monitoring methods were more robust.

Similarly, the proliferation of commercially available small sensors is promising, but federal reference methods for all of the criteria pollutants demand more precision and accuracy than the new sensors can currently deliver. This puts states in the difficult position of trying to provide the public with the increasing amount of real-time data they have come to expect, and yet needing to rely on expensive older technology to provide it. Continuing research and development of new monitoring technology that meets FRM criteria is urgently needed to reduce the burden of maintaining aging equipment and bringing the public data that is easily accessible and of high quality.

Can any existing sites be shut down? Should new sites be added? Shutdowns of PM2.5 and ozone sites are very difficult if not impossible because of extremely stringent criteria set by EPA. Even when sites are identified as highly correlated and of low value, most have a higher than 10% probability of measuring 80% of the NAAQS and are consequently not eligible. This analysis identified only 1 of more than 200 ozone monitors that met that criteria, and only 10 of 124 PM2.5 monitors, all in the far northern part of the region. EPA should consider relaxing this requirement so states can shut down highly correlated monitors in dense urban networks where multiple monitors are measuring the same air mass and not providing unique information. The current criteria for shutdowns gives too much emphasis to high concentrations and not enough to the relative value of each site in terms of the airshed it monitors.

Also of concern are recent EPA decisions to defund rural and low concentration PM2.5 speciation monitors. The reliance on IMPROVE monitors to provide rural data is understandable, but IMPROVE is also undergoing funding shortfalls and shutdowns so maintaining adequate geographic coverage is more difficult. These sites are important for model validation and for characterizing upwind and background concentrations. These background sites tend to be undervalued because they typically have low concentrations, but NAAQS and high concentrations are not the only justification for maintaining monitors. SIP modeling to develop control programs relies on those rural, upwind, and non-urban measurements of ozone, PM2.5 mass, speciation, and precursor gases to provide defensible results. In particular, as concentrations fall, the role of background concentrations vs. local emissions becomes both more critical to understand and more difficult to distinguish, reinforcing the need for such measurements.

Other criteria pollutants. With respect to other criteria pollutants, the NO2 near-roadway sites have been difficult to establish and have high operating costs. Until the value of measurements so close to roadways is established, it is recommended that Phase 3 implementation in smaller cities be postponed or eliminated. At the population-based NO2 sites, concentrations are much below the NAAQS and all monitoring is in urban areas. As noted above, some expansion to rural and upwind sites is recommended, especially in light of a potentially much more restrictive ozone standard.

The SO2 network is focused on large sources, and the emissions density analysis shows that the distribution of sites provides excellent coverage in areas of high emissions. The proposed data requirements rule allows for SO2 monitors for attainment demonstration purposes, but there is uncertainty about where these monitors may be set up as the rule and accompanying technical assistance documents are not final at this time. Affected industrial facilities may pay for some sites, but even without costs for infrastructure states will still be responsible for quality assurance of data and equipment.

The lead network underwent an expansion and transition to source-oriented measurements when the standard was lowered. Concentrations at population based sites are very low. States expect to shut down a number of the new sites that look like they will have 3 years of clean data. Some small cost savings should result from these actions.

Like lead and SO2, PM10 is a source oriented network with few monitors measuring concentrations over the NAAQS.

New priorities. The expected new ozone standard will require greater efforts to control precursors in cities that have not previously been scrutinized. The challenge of reaching lower O3 concentrations across a broader geographic area will create a monitoring burden for PAMS or PAMS-like measurements, but also for background precursor measurements, especially NOx, in low concentration areas. These are critical to support transport assessments. In addition, smaller scale meteorological phenomena like lake breezes have a large effect on most R5 state O3 exceedances. A better understanding of these influences will be imperative. Field studies would be helpful to identify the conditions that control the extent of lake breeze development and improve our ability to model its behavior and impact on ozone concentrations.

As PM2.5 concentrations continue to respond to SO2 and NOx controls, the atmospheric chemistry that governs PM2.5 formation becomes more sensitive to ammonia (NH3). Increasing industrialization of farming operations and the resulting concentration of ammonia emissions means that there is a need for greater understanding of this PM2.5 precursor gas. Despite the prominent role of ammonia, no national network currently tracks ambient concentrations or trends, although NADP has found some support for limited measurements. As was stated for ozone precursors above, accurate modeling of PM2.5 is dependent on understanding ambient concentrations of the major precursors. There is a clear need for better ammonia characterization across the Midwest, including development of monitoring methods with good time resolution and sensitivity over a wide range of ambient concentrations. EPA should support research in this area.

All of the R5 states have fish consumption advisories based on mercury, yet there is no stable funding available for mercury measurement. In light of the recently implemented MATS rule and its requirement for mercury controls, a consistent network is needed to track trends and develop estimates of local contributions and long range transport.

There are increasingly other pressures on state air agencies that challenge staff and resources beyond routine network operations. These include increased expectations from the public for data, ad hoc monitoring for local issues, and the need to access the AQS database, which has had reliability issues and reduced EPA support making data uploads and downloads more challenging.

EPA should carefully prioritize work and needs in monitoring networks, based on available resources.

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