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

2020 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. Most of the data are presented in an ArcGIS Story Map that is accessible to anyone through the following link: https://arcg.is/14Webz

An additional web tool was developed by the state workgroup for this assessment. It builds on EPA's NetAssess App by adding toxics data to its database and incorporating cancer risk from the 2014 National Air Toxics Assessment. This particular tool has a complex history, having been first developed by EPA in 2010, then rewritten by members of the LADCO workgroup in 2015, and revised again by EPA in this review cycle. The NetAssess App with toxics and risk additions is accessed from within the story map.

Each of the analyses performed as part of this assessment are presented as a map or a layer within a map that can be selected and viewed. The platform allows the user to interact by zooming to any area of interest. Additional details about each monitor and the relevant data for that layer are available by clicking on any specific monitor. It is also possible to download the underlying data for most maps.

This assessment focuses 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 400 criteria pollutant monitoring sites at an annual 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, correlation analysis, cluster analysis, exceedance probability, design value, trend magnitude and direction, unmonitored area analysis (in combination with gridded emission inventory analysis), length of record, number of parameters monitored, monitor shutdown criteria, and an overall ranking. Small sensor use throughout the region was assessed by surveying states and their potential for broader use was evaluated. Toxics network coverage was assessed by examining monitor placement relative to lifetime cancer risk estimates.

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 monitoring technology is expensive to replace. Repair and maintenance costs are considerable. Continuing research and development of new monitoring technology that meets FRM criteria is needed to reduce the burden of maintaining aging equipment and bringing the public data that is easily accessible and of high quality. The proliferation of commercially available small sensors is promising, and the technology is increasingly being used by the public and regulatory agencies. While falling short of being adequate for regulatory purposes, agencies continue to research and gain insight on sensor operations, practices to improve data accuracy, and appropriate ways to interpret and present the data produced from these low cost units. The R5 state agencies continue to look towards EPA to provide direction, tools and resources to move towards a more consistent national approach.

2. Shutdowns of 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. 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. Because PM2.5 concentrations have declined significantly in the last 5 years, 54 PM2.5 sites meet the PM2.5 annual standard exceedance threshold and 96 sites meet the PM2.5 daily standard exceedance threshold. Some of these sites may be candidates for shutdowns if they are not required for other reasons. Any future tightening of the PM2.5 NAAQS will change this assessment. As PM2.5 concentrations continue to respond to SO2 and NOx controls and the public health risk lessens, it becomes a lower priority. Most states are transitioning their networks to FEMs to take advantage of cost savings and more temporally resolved data. Sites with concentrations closest to the NAAQS will remain FRMs.

4. Accurate SIP modeling of PM2.5 and ozone is dependent on understanding ambient concentrations of the major precursors. Shutdowns of some rural and low concentration monitors jeopardizes important SIP tasks of model validation and characterization of upwind and background concentrations. IMPROVE and CASTNET monitors provide some backup to gaps in the state networks but in recent years the both programs have experienced flat funding and rising costs, which 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. Ammonia is a PM2.5 precursor that is poorly characterized. EPA should support development of NH3 monitoring methods with good time resolution and sensitivity over a wide range of ambient concentrations.

5. The SO_2 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 SO_2 network was further developed due to the SO_2 data requirements rule which resulted in the addition of 5 monitoring sites in the region (some states added more monitors and two states shut down more than were added). Many other facilities were considered but took alternative steps of adjusting their permits to include more stringent limits or demonstrated attainment through modeling analysis.

6. The rollout of the revised PAMS network has been rocky. Many agencies have had trouble obtaining equipment, largely due to funding issues, and most have not yet achieved fully instrumented sites. The additional challenge of reaching more stringent O_3 standards across a broader geographic area continues to create a need for PAMS or Enhanced Ozone Monitoring, including background precursor measurements, especially NO_x. EPA needs to commit sufficient funding to allow states to obtain and maintain the sophisticated instruments needed for these measurements.

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 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 web tools were developed by the state workgroup for this assessment. The first, called NetAssess2020 (https://dereknagel.shinyapps.io/netassess2020-master/), was a major modification of the analytical tools that EPA produced for the 2020 5-year assessment. The history of NetAssess is somewhat tangled. It was first developed by Mike Rizzo at EPA for the 2010 assessments, then updated and modified by LADCO analysts for the 2015 assessments. In this most recent iteration, EPA updated the platform for criteria pollutants. The LADCO workgroup then added data on toxic pollutants and cancer risk. 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 ESRI's ArcGIS Online as a Story Map (Story Map Link). Each of the analyses performed as part of this assessment is presented as a layer that can be selected and viewed on the map. Data for this tool are shown for the entire country for some analyses, but the assessment is performed 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, gridded emissions, analysis results, monitor rankings, and toxics and risk information.

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.

Overview of Current Networks

The state and local agencies in Region 5 currently operate over 400 criteria pollutant monitoring sites at an annual cost of over $20 million. Maps of the networks for each pollutant are available at the following link (Story Map Link). Since the last 5-year assessment, the states have met a number of challenges, including establishing new PAMS sites; establishing new SO2 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 balancing public expectations of real-time air quality data with the limitations of budgets and small sensor performance.

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, correlation analysis
Support compliance with NAAQS	Attainment analysis	Concentration-based analyses: Design value ranking, trend analysis, unmonitored area analysis (emission inventory and exceedance probability)
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

ArcGIS Story Map

The ArcGIS Story Map can be accessed at https://arcg.is/14Webz. The maps (described further below) include nonattainment areas for all criteria pollutants; gridded emissions for SO2, NOx, and VOCs; design values for all criteria pollutants; ozone monitor rankings for 6 individual criteria (area served, population served, design value, trend, correlation with other sites, and exceedance probability); PM2.5 monitor rankings for the same set of criteria; an overall ranking that includes the average ozone and PM2.5 ranks and ranks for number of parameters monitored, number of years of record, and population change. Cluster analysis by state shows which monitors are most closely related and measuring similar air masses. Data and maps of the toxics monitoring network and cancer risks from the NATA risk assessment are included but are not incorporated in the monitor ranking. The sections are described individually below.

Introduction and 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 1 shows ozone nonattainment areas as an example. Layers for each pollutant can be turned on or off and overlaid. These layers reflect the most recent maps available from EPA, but note that some redesignation requests are being processed at the time of this assessment and are not included in these maps. The most recent regulatory data is available from the Green Book at https://www.epa.gov/green-book. This introductory section also includes information about navigating through the Story Map and how to access layers, legends, and underlying data. This information remains the same throughout the different sections.

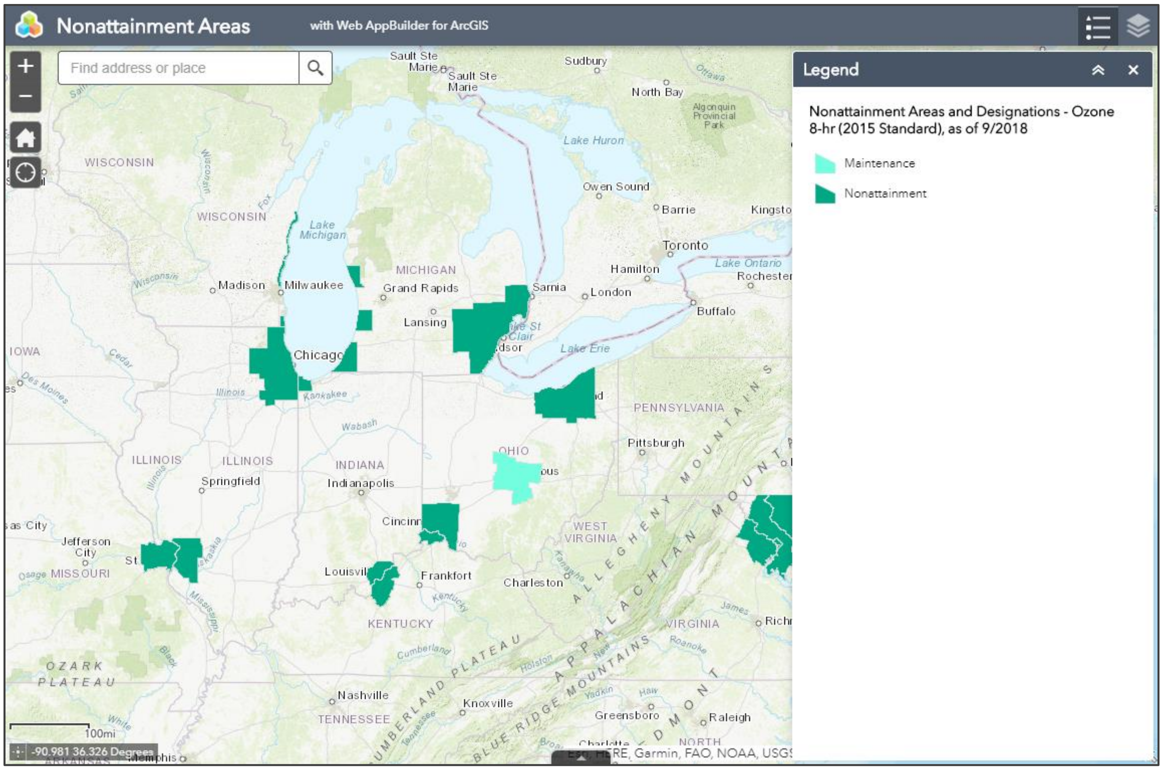

Figure 1. Example of Nonattainment Map Layers (map source: US EPA)

Monitoring Networks. Maps of the various networks make up the next section of the Story Map. The section opens with a map of all 400+ monitors, showing the number of parameters measured at each (Fig. 2). Some sites measure only one pollutant, others have multiple monitors and measure many pollutant species. Having multiple pollutant species measured at the same site can make that site more valuable to analysts who use the data to interpret related health impacts and determine the emission sources contributing to a community's air pollution. In this analysis, we assign a higher rank to sites that measure multiple pollutants. 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 1 to 5 by the number of pollutants that are measured, with 1 assigned to sites measuring the most pollutants and 5 to sites that have the fewest pollutants.

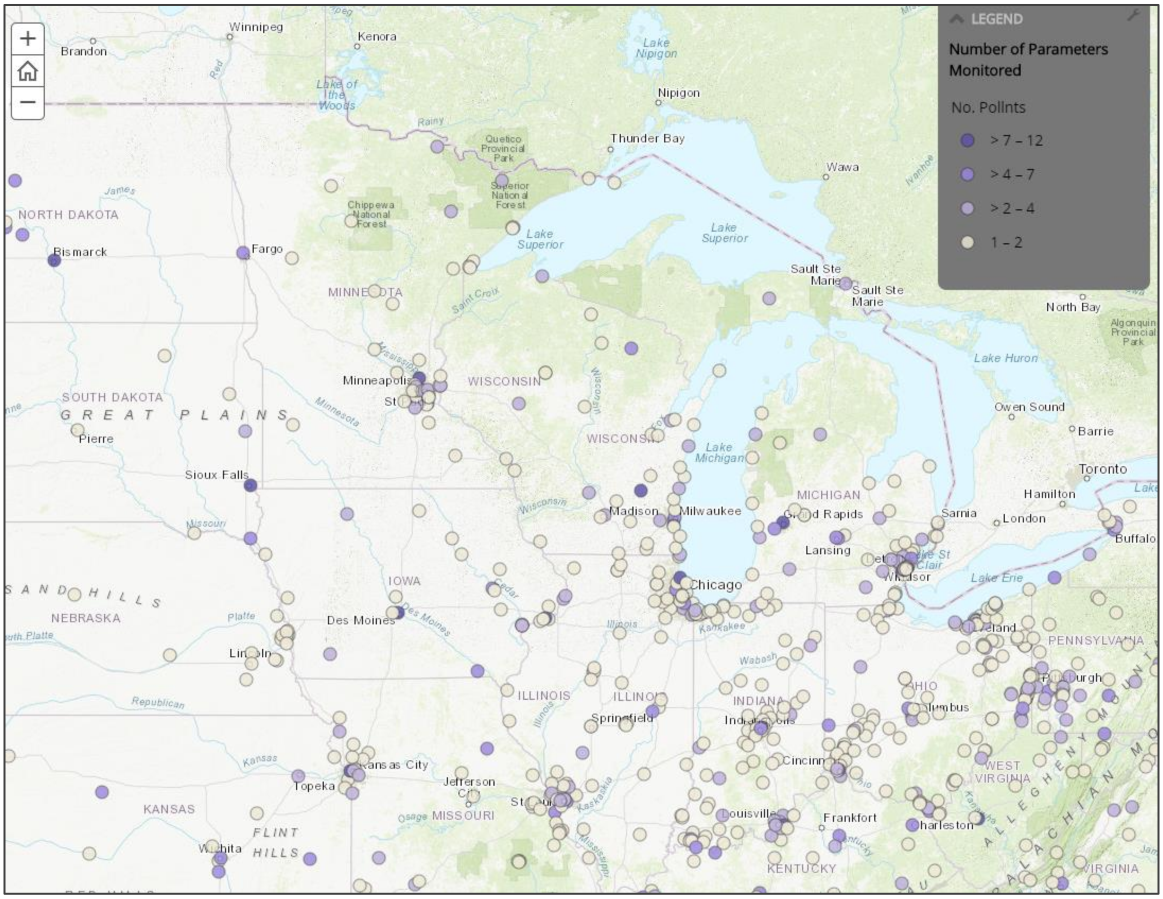

Figure 2. Example of Monitoring Network Maps Showing Number of Parameters

Additional networks shown include NCORE, PAMS, PM2.5 chemical speciation, meteorological monitors, air toxics monitors, and IMPROVE visibility monitors. Ozone and PM2.5 criteria monitoring are presented as separate sections.

Ozone and PM2.5 Monitor Rankings. Ozone and PM2.5 sites were evaluated separately on the basis of 6 criteria: population served, area served, design value, trend, correlation with other sites, and exceedance probability. Absolute values for each of the criteria were converted to ranks from 1 to 5 (quintiles), with 1 the highest rank and 5 the lowest rank. The 6 individual ranks were then averaged for an overall ranking. Each criteria ranking as well as the overall rank is mapped. The actual values are accessible through popup boxes and by opening the data table at the bottom of the maps. Raw data for these analyses, along with the calculated ranks, are also available at: Monitor data and rankings.

Design Value and Trends. 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 2016-2018 and trends from 2010-2018. Monitoring sites with high concentrations are important because they reflect higher risks to public health from ozone exposure. Similarly, sites with increasing trends are given more weight because they indicate a failure to respond to decreasing emissions and potentially a greater threat to public health. Very few sites in Region 5 have increasing trends (as shown by the red arrows) and the magnitude of increase is small (see Fig. 3). Most sites are decreasing or show no trend (flat). These are depicted by the green arrows and black dots. Sites shown with gray dots did not have sufficient data to determine a trend over the 2010-2018 time period. Specific data for each site is available by clicking on the dots or arrows and scrolling through the popup box.

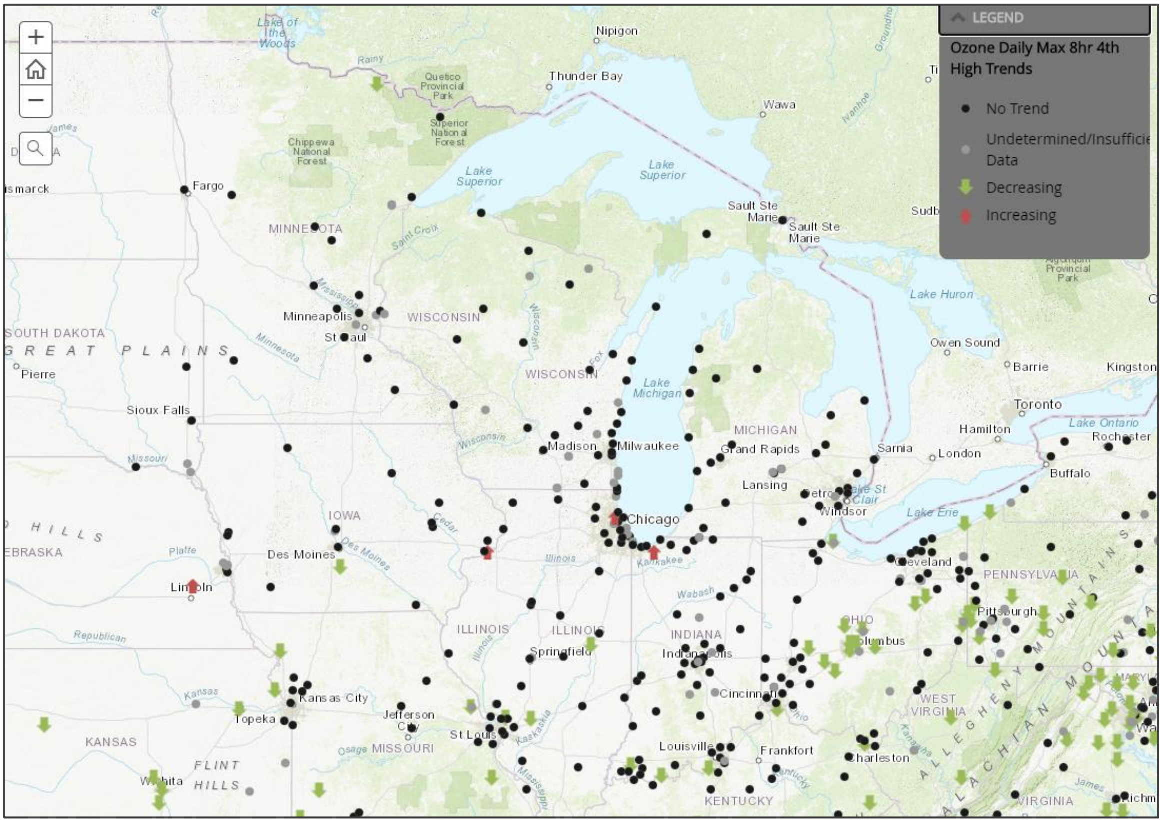

Figure 3. Ozone Trends

Population and Area Served Ranks. Ranks for population and area served by each monitor were developed from output of the NetAssess2020 tool. 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 is determined from US Census data, as well as associated demographic data distributions by gender, age, and race. Ranks were assigned from 1 to 5, with 1 for monitors with the highest population (upper 20%) and 1 for monitors with the least population (lowest 20%). See Fig. 4 for an example of this ranked analysis.

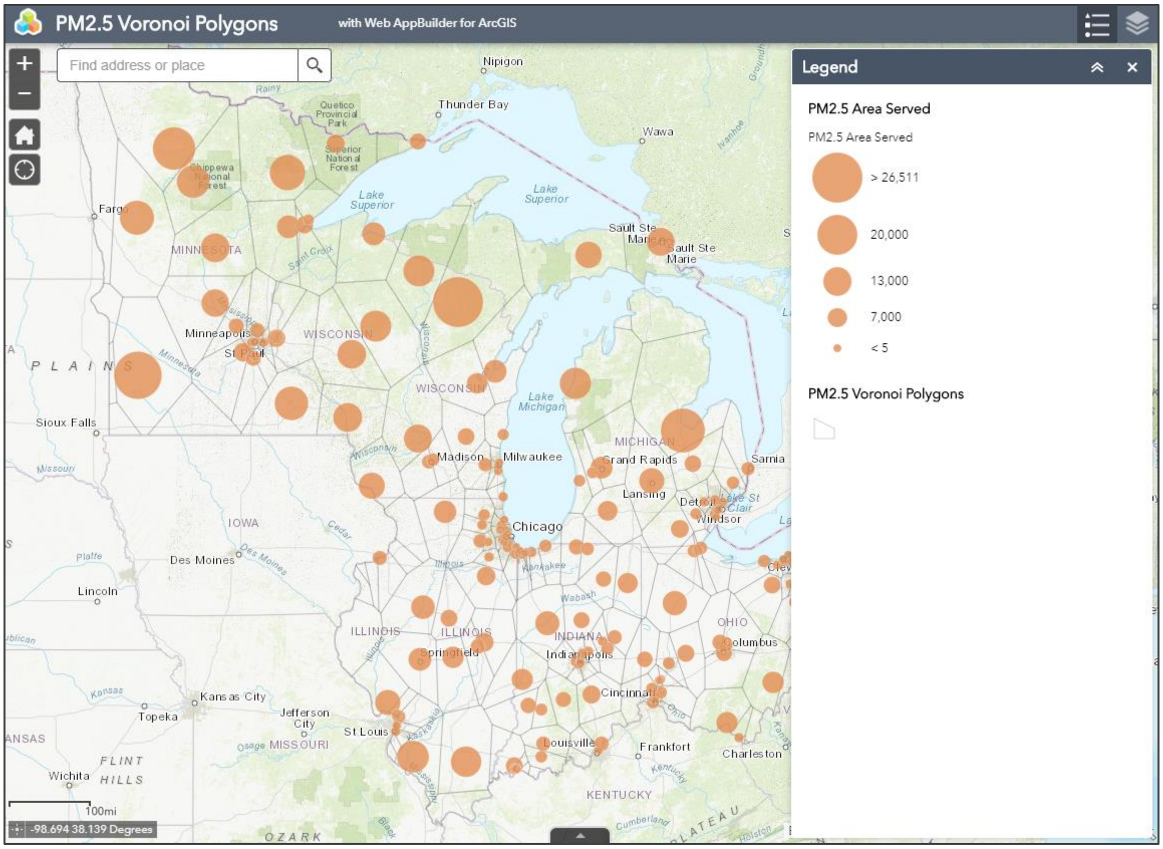

Fig. 4 Example Map of PM2.5 Area Served Rankings and Voronoi Polygons

Exceedance Probability. Exceedance probabilities were calculated by US EPA for each U.S. census tract, based on 2014-2016 data, and these probabilities were then mapped (Figure 5 shows these probabilities for PM2.5). The areas on the map shown in hot colors are those most likely to exceed the NAAQS. The surface shows the probability of exceeding the 2015 8-hour NAAQS based on 2014-2016 data (i.e., probability of having a 2014-2016 DV > 70 ppb). To calculate these values, EPA used a data fusion process called Downscaler to merge monitored daily max 8-hour values from AQS with modeled daily max 8-hour values from CMAQ. Downscaler returns a prediction (mean) and uncertainty (standard deviation) for each census tract, for each day in 2014-2016. Those predictions are then bootstrapped to create 1,000 random daily time series for each census tract based on their respective predictions and uncertainties. The exceedance probability for each census tract is the percent of these random time series that produced a design value above the NAAQS.

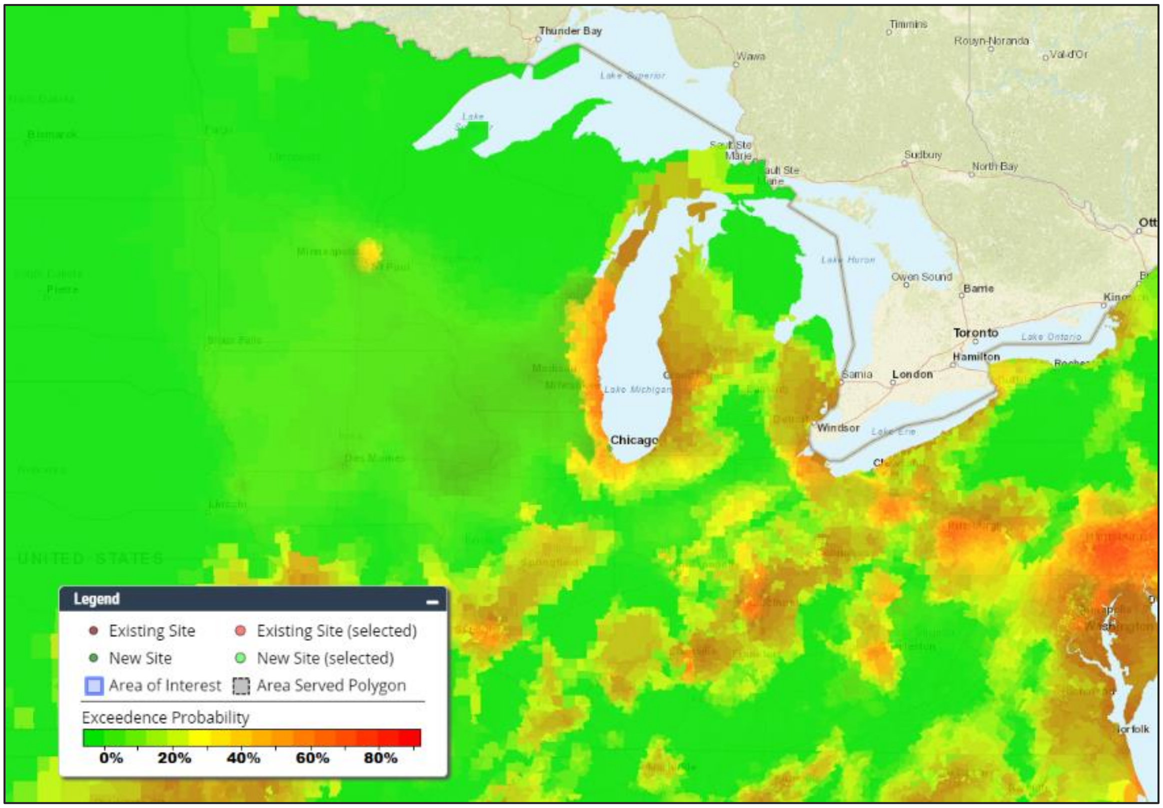

Figure 5. PM2.5 Exceedance Probabilities

These exceedances are useful for evaluating whether there are areas that have a high probability of exceeding the NAAQS but don't currently have monitors. For shutdown decisions, EPA requires a different metric and the following conditions:

1. The PM2.5 monitor showed attainment during the previous five years.
2. The probability is less than 10% that the monitor will exceed 80% of the applicable NAAQS during the next three years based on the concentrations, trends, and variability observed in the past.
3. The monitor is not specifically required by an attainment plan or maintenance plan.
4. The monitor is not the last monitor in a nonattainment area or maintenance area that contains a contingency measure triggered by an air quality concentration in the latest attainment or maintenance plan adopted by the state and approved by EPA.

The probabilities for bullet 2 were calculated using the method described in EPA-454/D-07-001, Ambient Air Monitoring Network Assessment Guidance, for the 2014-2018 design values. Those calculations show that most PM2.5 monitors in Region 5 meet the threshold of less than 10% probability of exceeding 80% of the NAAQS (0.056 ppb). Of 95 monitors that met the data completeness requirement, 93 meet the threshold for the daily NAAQS and 54 meet the threshold for the annual standard.

Correlations and Clusters. Pearson correlations between all pairs of ozone monitors and PM2.5 monitors were calculated over 2016-2018. The highest correlation for each monitor was used to assign a rank from 1 (high) to 5 (low). Both ozone and PM2.5 are regional pollutants and thus tend to have high correlations over a large geographic area. Correlations and associated statistics can also be calculated for any selected set of monitors with the NetAssess2020 tool, found under the Toxics and Risk tab in the Story Map (Fig 6). 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.

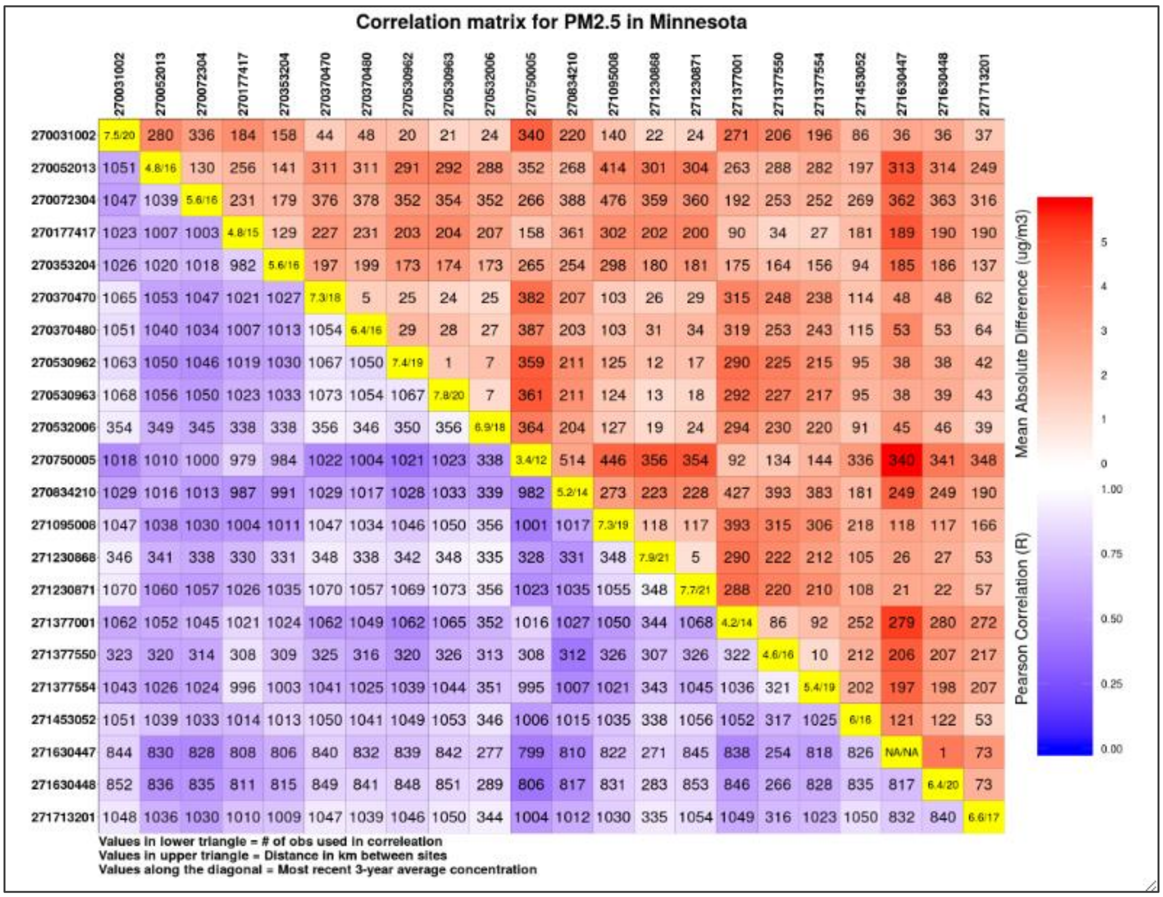

Figure 6. Example Output from the NetAssess2020 Correlation Tool

Cluster analysis was performed for PM2.5 and ozone monitors in each state to see which monitors are closely related. This analysis moves beyond the pairwise correlation analysis by drawing a picture of the interrelationships of the entire state network. The degree of clustering can be used to evaluate how much unique information is provided by monitors. The analysis was performed on 2016-2018 PM2.5 data using the every-6th-day observations, and ozone season 8-hr daily maxes for 2016-2018. Cluster analysis requires a dataset without missing data, so the data were restricted to sites with mostly complete data records over the time periods, and missing observations were filled in with daily statewide averages if necessary.

Figure 7 shows trees that represent the PM2.5 clusters for Illinois. Sites that are most similar have the shortest 'branches' and are closest to each other on the tree. Long branches indicate sites that are less correlated with others and thus provide more unique data. Sites in all states display strong clusters by geography, although no geographic information is included in the clustering process.

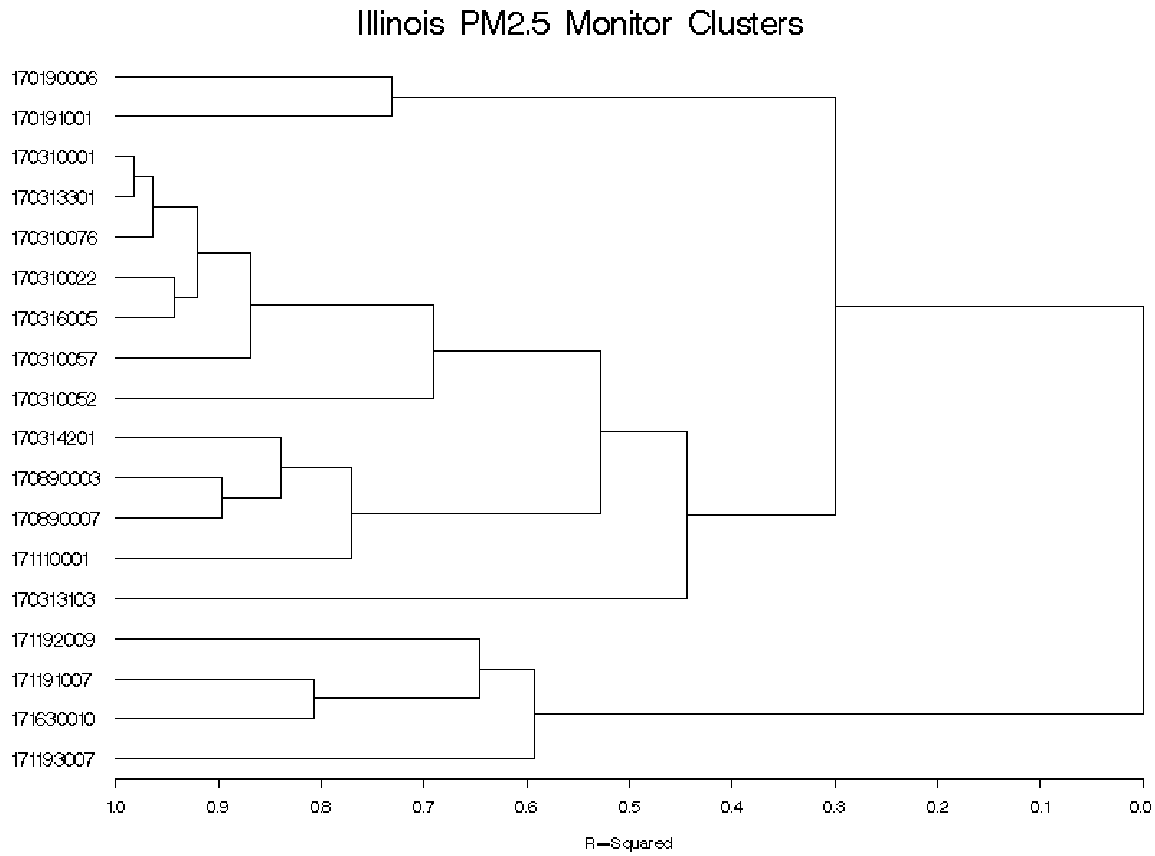

Figure 7. PM2.5 Clusters for Illinois

Emissions. Emissions of SO2, NO2, and VOCs from the LADCO 2016 inventory are plotted on the national 12-kilometer grid used for photochemical modeling, along with monitor locations. 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: https://www.epa.gov/air-emissions-inventories.

By comparing monitor locations with the distribution of emissions, one can see that the SO2 network has excellent coverage of the highest emission areas (see Fig. 8, for example). The NOx network is much less dense. Because ambient NO2 concentrations are low, the current network is adequate for NAAQS determination. 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. 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.

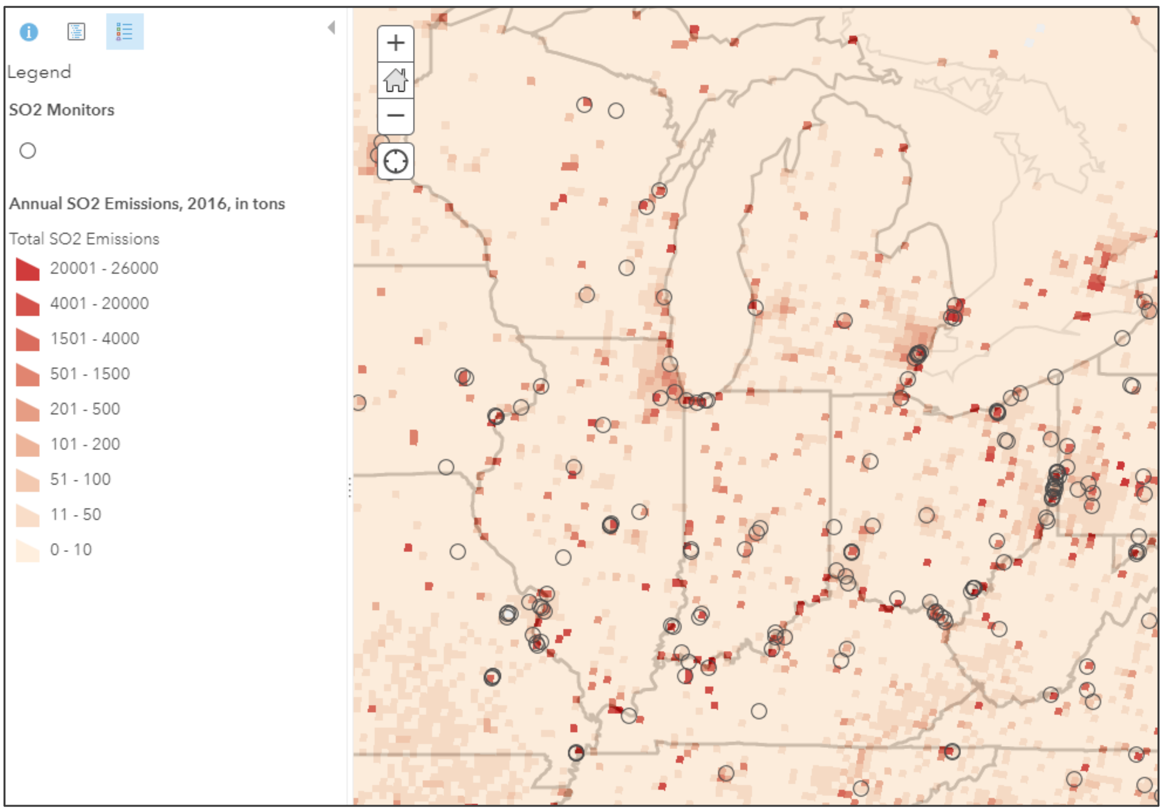

Figure 8. Example Map of SO2 Emissions Density and Monitor Locations

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. Consequently it is critical to monitor their concentrations in ambient air to provide air pollution models with information for assessing performance and understanding atmospheric chemistry. In addition to anthropogenic sources such as gasoline and solvent evaporation, biogenic sources (plants) are a major part of the inventory. The VOC map shows both anthropogenic and biogenic emissions. Areas of densest emissions correspond to large urban areas as well as the oak forests of the Ozarks and pine forests in the southeastern US. Sites that monitor for VOCs and carbonyls are indicated by yellow and blue dots.

Small Sensors. Sensor technology is becoming more prevalent in the U.S. and around the world. Sensors allow for the collection of more data in more places at a much lower cost than regulatory methods required by EPA. The downside is that sensor technology data quality and reliability is much more variable and can lead to challenges dealing with the data and with public perceptions.

As part of the 5-year network assessment for Region 5, monitoring agencies were surveyed regarding sensor use and evaluation within and outside of their organizations. Thirteen responses were received from a variety of state and local regulatory agencies, tribal agencies and LADCO.

Nearly half the survey respondents indicated they had some experience using or evaluating one or more sensor technologies. PurpleAir was the most frequently identified sensor technology. Other sensor technologies mentioned included: Dylos, Clarity Node, Aeroqual AOY, Aeroqual 500, Sensit Ramp, Applied Particle Technology Maxima, Air Beams, AQ Mesh, Pods and Array of Things (AoT).

All but one respondent indicated that they may consider or expect to evaluate or work with sensor technology in the next five years. Projects are expected to include continuing or starting evaluation studies, working with citizen science as a resource, outreach and education efforts.

Less than half of respondents indicated any current intentions to use sensors in their regulatory network. Respondents who indicated they would consider using sensor technology indicated this would be in limited fashion such as evaluating how to enhance existing network, AQI forecasting, site selection, identifying problem areas or responding to specific public concerns and complaints.

Respondents identified many challenges with using sensor data. In general, regulatory agencies indicated their concern with having time and resources to develop sensor expertise and the ability to comment on sensor data. There were also concerns with the quality of the data produced by sensors and the misconception that sensor data may be of equal validity as FEM/FRM data produced by regulatory agencies. Managing and evaluating data produced by sensors is complicated by the lack of a standard for comparison, unknown sensor algorithms, and unknown accuracy and precision of sensor data.

Communicating these and other concerns with the public was also identified as a challenge. This is a valid concern considering that most of the respondents were aware of one or more external groups using sensor technology for a variety of purposes including collocation evaluations, design and development, residential air quality and source investigation.

Most of the respondents were aware of national tools such as EPA's sensor toolbox and SCAQMD's AQ-Spec. Similarly most respondents were interested in participating in some type of workgroup to share knowledge and challenges related to sensor technology.

Toxics and Risk. Toxics data for Region 5 and some surrounding states was been incorporated into the EPA NetAssess2020, and a layer with NATA cancer risks for the country was added (source: National Air Toxics Assessment, https://www.epa.gov/national-air-toxics-assessment/2014-nata-map). Examining the location of toxics monitors in relation to the cancer risk estimates can reveal areas that are under-served and may be considered for additional monitoring (Fig. 9). In addition to the toxics component, the NetAssess suite of tools provides online results for criteria pollutants and 4 different analyses are available for use with any pollutant: area and population served, correlations, exceedance probability, and removal bias

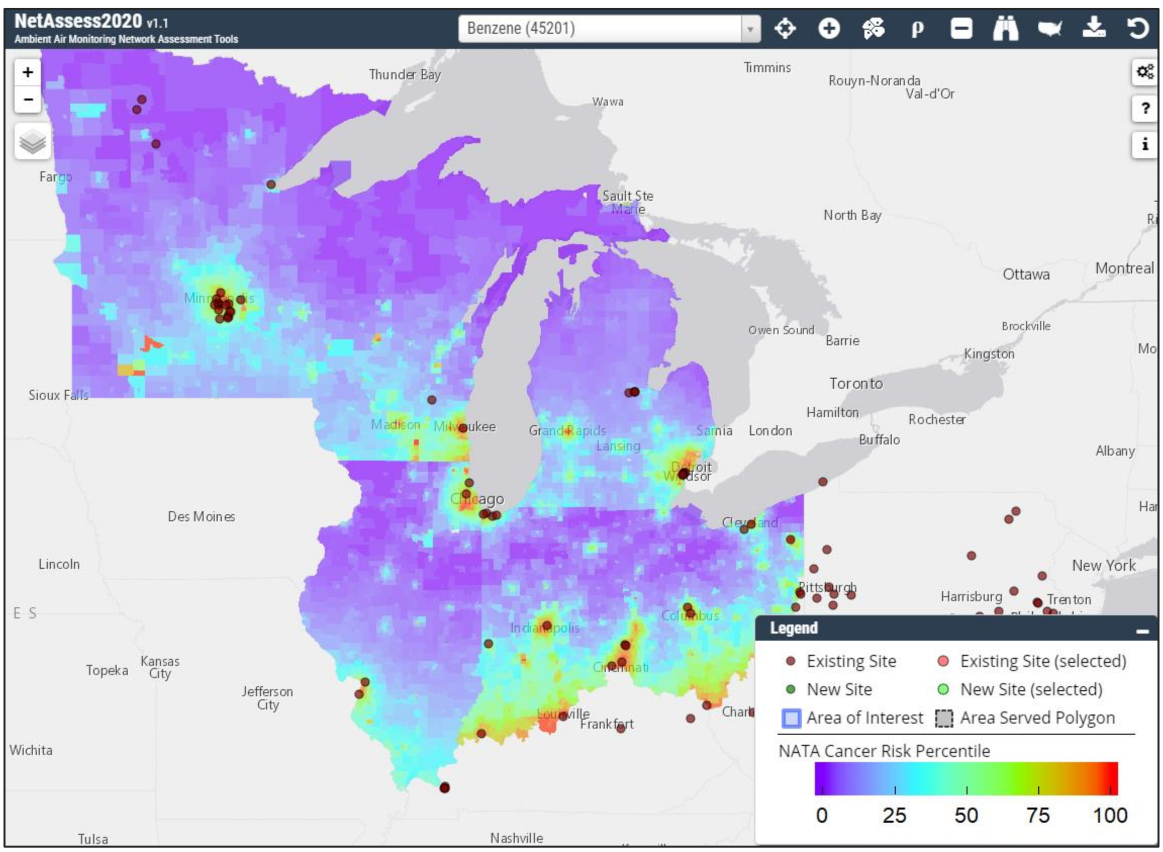

Figure 9. NATA Cancer Risk Percentile and Benzene Monitoring Sites.

Overall Ranks. An overall rank was developed for all monitors by averaging the PM2.5 scores, ozone scores, and scores for number of years monitored, number of parameters monitored, and population trends in the county containing the monitor. Each analysis was given equal weight, although states and other users may prefer to assign different weights to different analyses. Fig. 10 shows an example of the overall rankings from the

Story Map. The raw data is available for those interested at: [Monitor data and rankings](). 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. Similarly, sites with many different species monitored score high, because the added parameters can make that site more valuable to analysts who use the data to interpret related health impacts and determine the emission sources contributing to a community's air pollution. Cost efficiencies from consolidating monitors to fewer sites also factor in. Population trends in the counties were examined because increasing population can mean the monitor represents a larger population at risk. Trends in either direction were ranked higher than no trend in this analysis.

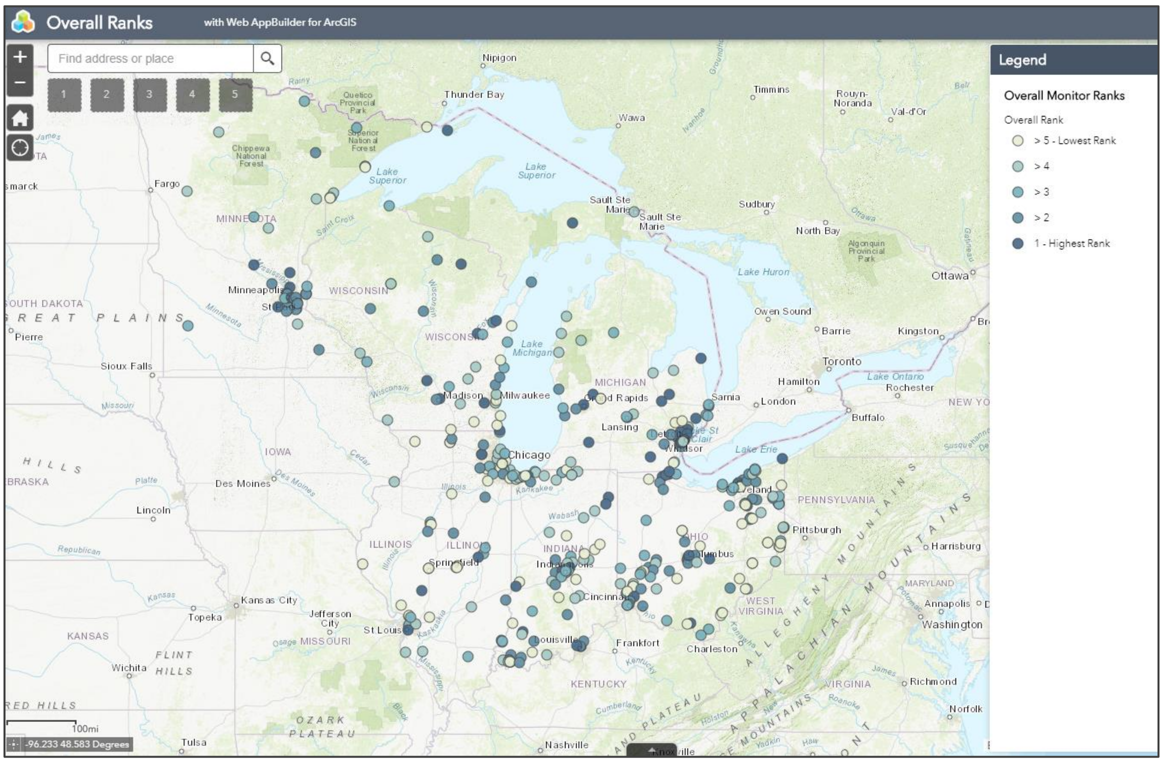

Figure 10. Example of Overall Rankings

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 it can be used to find potential candidates to examine 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. Of the four criteria that a monitor must meet, one in particular is extremely stringent. As discussed in the section on exceedance probability, 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. Only one ozone monitor of more than 200 met EPA's shutdown criteria as described in 48 CFR 58.14(c). For PM2.5, the picture was much better; 93 meet the threshold for the daily NAAQS and 54 meet the threshold for the annual standard.

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.

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. The proliferation of commercially available small sensors is promising, but federal reference methods for all 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 needed to reduce the burden of maintaining aging equipment and bringing the public data that is easily accessible and of high quality. States will continue to rely on national programs to assist in making small sensor data useable and easy for the public to understand.

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. 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. Because PM2.5 concentrations have declined significantly in the last 5 years, 54 PM2.5 sites meet the PM2.5 annual standard exceedance threshold and 96 sites meet the PM2.5 daily standard exceedance threshold (see Appendix for a site list). Some of these sites may be candidates for shutdowns if they are not required for other reasons. Any future tightening of the PM2.5 NAAQS will change this assessment.

Shutdowns of rural or low concentration monitors must be done cautiously, to avoid jeopardizing the important SIP tasks of model validation and characterization of upwind and background concentrations. 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 were difficult to establish and have high operating costs. Most are now monitoring other pollutants as well, generally CO but also some PM2.5 and black carbon. Based on Phase 2 data, in 2016 EPA removed the requirement for near-road NO2 monitoring stations in Core Based Statistical Areas (CBSAs) having populations between 500,000 and 1,000,000 persons. 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.

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 data requirements rule resulted in a net increase of 5 monitors across the region, although some states were able to shut down more monitors than were added.

The lead network underwent an expansion and transition to source-oriented measurements when the standard was lowered in .2008. Concentrations at population-based sites are very low. Since the last 5-year assessment, 15 lead monitors have been shut down, resulting in cost savings to the states.

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

New priorities. The 2015 ozone standard has created a need to control precursors in cities that have not previously been in nonattainment. The challenge of reaching lower O3 concentrations across a broader geographic area has created a need for both PAMS or enhanced ozone measurements, and also for background precursor measurements, especially NOx, in low concentration areas. These data 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 is 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 and the public health risk lessens, it becomes a lower priority. Most states are transitioning their networks to FEMs to take advantage of cost savings and more temporally resolved data. Sites with concentrations closest to the NAAQS will remain FRMs. As with ozone precursors, accurate SIP modeling of PM2.5 is dependent on understanding ambient concentrations of the major precursors. There is a 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.

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. Environmental justice issues are a priority that some states are addressing in part with small sensors.

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

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Appendix: Sites that meet the EPA criteria for shutdown

This table lists sites where the probability is less than 10% that the monitor will exceed 80% of the applicable NAAQS during the next three years based on the concentrations, trends, and variability observed in the past. This is not a recommendation for shutting down sites; that decision is based on many other criteria as well.

AQS Site ID	Local Site Name	Under O3 CL?	Under Ann.PM CL?	Under Daily PM CL?	2018 Ozone Design Value	2018 PM2.5 Annual DV	2018 PM2.5 Daily DV
180030004	Ft. Wayne- Beacon St.			yes	0.066	8.6	21
180190008	Charlestown State Park		yes	yes	0.07	7.7	17
180350006	Muncie- Central HS			yes		7.9	17
180372001	Jasper PO			yes		8.6	20
180550001	Plummer			yes	0.067	7.9	19
180650003	Mechanicsburg- Shenandoah HS		yes	yes		7.5	16
180890031	Gary- Madison St./ Gary Water/ IN American W			yes		9.4	23
180950011	Anderson- Eastside Elem. School			yes		8.3	18
180970078	Indpls- Washington Park			yes	0.069	8.9	20
180970081	Indpls- W. 18th St./ Ernie Pyle School 90			yes		10	23
180970083	Indpls- E. Michigan St./ Thomas Gregg Sch. 1			yes		9.8	22
181270024	Ogden Dunes- Water Treatment Plant			yes	0.071	7.7	19
181470009	DAVID TURNHAM ELEMENTARY SCHOOL,			yes		8.4	18
181630016	Evansville- U of E/ University of Evansvill			yes		9	19
181630021	Evansville- Buena Vista			yes	0.068	8.5	18
181670018	TERRE HAUTE CAAP/ McLean High School			yes	0.068	9	22
260050003	Holland		yes	yes	0.073	7.4	21
260170014	Bay City		yes	yes		6.9	20
260490021	Flint		yes	yes	0.068	7.2	19
260770008	KALAMAZOO		yes	yes	0.071	8.2	21
260810020	Grand Rapids		yes	yes	0.07	8.2	20
260910007	Tecumseh		yes	yes	0.068	7.6	19
260990009	New Haven		yes	yes	0.072	7.6	19
261010922	Little River Band of Ottawa Indians		yes	yes	0.066	5.8	16
261130001	Houghton Lake		yes	yes	0.067	5	15
261250001	Oak Park		yes	yes	0.073	8.1	20
261470005	Port Huron		yes	yes	0.072	8	19
261610008	Ypsilanti		yes	yes	0.069	8.1	19
261630001	Allen Park			yes	0.068	8.8	22
261630015	Southwestern H.S.			yes		11.3	28

261630016	Linwood			yes		8.9	22
261630019	East 7 Mile		yes	yes	0.074	8.1	19
261630025	Livonia		yes	yes		7.9	19
261630033	Dearborn			yes		10.6	25
261630036	Wyandotte		yes	yes		7.6	20
270031002	Anoka County Airport		yes	yes	0.063	7.3	20
270370470	Apple Valley		yes	yes		7.1	17
270530963	Andersen School		yes	yes		7.6	20
270532006	St. Louis Park City Hall		yes	yes		6.9	18
270834210	Southwest Minnesota Regional Airport		yes	yes	0.06	5.2	14
271095008	Ben Franklin School		yes	yes	0.06	7.1	18
271230868	Ramsey Health Center		yes	yes		7.9	21
271230871	Harding High School		yes	yes		7.4	20
271377001	Virginia City Hall		yes	yes		4.2	14
271377550	U of M - Duluth	yes	yes	yes	0.053	4.3	15
271377554	Laura MacArthur School		yes	yes		5.2	17
271453052	Talahi School		yes	yes	0.061	6	16
271630448	Andersen Windows South		yes	yes		6.1	19
390090003	Gifford		yes	yes		6.4	12
390170016	Sacred Heart Elem			yes		8.8	19
390230005	Springfield Fire St1			yes		8.7	20
390350034	District 6		yes	yes	0.07	7.8	18
390350038	St Theodosius			yes		9.8	22
390350045	Cleveland Fire St13			yes		9.5	20
390350065	Harvard Yards			yes		11	23
390351002	Brookpark		yes	yes		7.9	18
390490081	Maple Canyon			yes	0.066	8.2	19
390570005	Yellow Springs		yes	yes		7.8	17
390610006	Sycamore			yes	0.075	9	19
390610014	Carthage			yes		9.7	21
390610040	Taft NCore			yes	0.072	9.1	20
390610042	Lower Price Hill			yes		9.2	20
390810017	Stuebenville			yes	0.062	9.5	22
390850007	Painesville		yes	yes	0.07	7	16
390870012	ODOT Ironton		yes	yes	0.065	6.6	15
390933002	Barr School		yes	yes		7.5	17
390950024	Erie			yes	0.069	8.5	20
390950026	RAPS			yes		8.1	18
390990014	Headstart			yes		7.9	17
391030004	Chippewa		yes	yes	0.065	7.6	18
391351001	Preble NCore		yes	yes	0.067	7.8	17

391510017	Canton Fire St8			yes		9.3	21
391510020	Canton			yes		9.2	20
391530017	East HS			yes		9	20
391530023	Five Points			yes		7.8	18
550030010	BAD RIVER TRIBAL SCHOOL - ODANAH		yes	yes	0.059	4.2	14
550090005	GREEN BAY EAST HIGH		yes	yes		6.4	18
550250041	MADISON EAST		yes	yes	0.065	8	21
550250047	MADISON - UNIVERSITY AVE WELL #6		yes	yes		8.1	22
550270001	HORICON WILDLIFE AREA		yes	yes	0.066	6.8	20
550350014	EAU CLAIRE - DOT SIGN SHOP		yes	yes	0.064	6.8	18
550430009	POTOSI		yes	yes		7.3	20
550590019	CHIWAUKEE PRAIRIE STATELINE		yes	yes	0.079	7.1	18
550630012	LACROSSE - DOT BUILDING		yes	yes	0.062	6.8	18
550790010	MILWAUKEE - SIXTEENTH ST. HEALTH CENTER			yes	0.067	8	20
550790026	MILWAUKEE - SER DNR HDQRS		yes	yes	0.069	7.6	20
550870009	APPLETON - AAL		yes	yes	0.065	6.3	19
550890009	HARRINGTON BEACH PARK		yes	yes	0.074	6.3	18
551110007	DEVILS LAKE PARK		yes	yes	0.064	6.5	17
551198001	PERKINSTOWN		yes	yes		5.5	16
551250001	TROUT LAKE		yes	yes	0.062	4.5	15
551330027	WAUKESHA - CLEVELAND AVE			yes	0.066	8.3	21