January 31, 2024

EPA-SAB-xx-xxx

The Honorable Michael S. Regan
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Subject: Transmittal of the DRAFT Science Advisory Board report entitled "Review of the Clean Air Status and Trends Ambient Air Monitoring Network (CASTNet)", dated September 10, 2023.

Dear Administrator Regan,

Please find enclosed the final report from the Science Advisory Board (SAB). The EPA's Office of Air and Radiation requested that the SAB review the Clean Air Status and Trends Network (CASTNet). In response to the EPA's request, the SAB assembled the SAB CASTNet Review Panel with subject matter experts to conduct the review.

The SAB CASTNet Review Panel met in-person from May 24 to 26th, 2023 to deliberate on responses to the agency's charge questions. On October 11, 2023, the Panel held a teleconference to discuss its draft report. Oral and written public comments were considered throughout the advisory process. This report conveys the consensus advice of the SAB.

While the SAB provides a number of recommendations in this report, we would like to highlight the following.

The SAB finds that CASTNet is a high value resource for state, local and tribal air agencies. The network is particularly valuable for unique features of spatial coverage, national consistency, its unique long-term data record, and the critical placement of monitoring stations to support the evolving national ambient air monitoring system over the next 10 years. The SAB notes existing gaps in spatial coverage and measurements that should be addressed in order to better support science and policy needs but overall CASTNet's geographic coverage is well positioned to support achievement of multiple EPA goals articulated in the EPA strategic plan.

The SAB finds that CASTNet is a unique network that, in its current configuration, is well designed and sited to provide long term, stable air quality monitoring program infrastructure (with substantial existing investments in power and communications systems, and partnerships maintenance and operations) for essential scientific understanding of air pollution, and support policy analysis and program accountability, especially in the contexts of climate change and environmental justice. This ongoing monitoring capability will be essential over the next 10 years, at least, to provide unique insight into air pollution chemistry and surface ozone trends (including constraints on background ozone amounts), and to develop a better understanding of rural to urban air pollution chemistry and the impacts of air pollution on different populations.

The network emphasizes national-scale coverage, methodological consistency, and long-term rural multi-pollutant monitoring of important chemical species such as ozone, acid rain (deposition), mercury, and sulfur, ammonia, and nitrogen compounds which are known precursors in the formation of particulate matter air pollution. Understanding these compounds is critical to developing and evaluating regulatory policy. CASTNet data are key for understanding the influences of climate change on air pollution and its impacts on public health, resources, and ecosystems. The rural data collected through CASTNet are critical to understanding climate change impacts on air quality trends and variability in air quality and deposition. CASTNet informs environmental inequity by providing data relevant to human health in disadvantaged rural areas, especially tribal lands. CASTNet data have been used to develop and evaluate atmospheric science, atmospheric chemical transport models, and total deposition models used in research and policy making at all levels of government.

In order to understand trends and variability in air quality and atmospheric deposition in the context of climate change, it is essential to maintain long-term air quality monitoring using consistent methods across nationally distributed rural sites. The SAB emphasizes that cuts in the number of monitoring sites (or changes in location) and reduced measurement quality and consistency across the network would severely degrade Agency and researchers' ability to identify the impacts of climate change on air quality. CASTNet data is one of the first datasets researchers, and hence policy makers, turn to when investigating climate change impacts on air quality. The CASTNet record is only now becoming long enough to perform the types of statistical analyses necessary for confident attribution of changes in surface ozone air pollution specifically to climate change.

Any proposed adjustment to CASTNet should value its unique set of characteristics. EPA should prioritize measurements that inform issues impacting rural areas on a national scale. These include multipollutant, coordinated measurements taken from observational platforms to monitor changing atmospheric chemistry and understand the transport, chemical transformation, and deposition of pollutants. These measurements are provided by the current configuration of CASTNet. CASTNet data have been critical in developing and evaluating atmospheric chemical transport models (including those coupled to global climate models that project air pollution into the 21st Century), and total deposition models used in research and policy at all levels of government. It is important that the EPA continue key long-term air quality measurement at existing, well-distributed sites. However, the SAB was also charged with exploring potential additional measurements and methods that would enhance the existing network or respond to anticipated future needs. The SAB has identified possible benefits of potential additional measurements, but we recommend that the overall objectives of the monitoring program drive prioritization of measurements taken at the network-scale. The SAB offers a new approach (in Appendix A) to articulate and prioritize scientific and policy objectives for the network and identify which monitoring site locations or combinations of locations best meet the overall needs of the agency. The tables in Appendix A contains suggested qualitative and quantitative metrics relevant to each of seven prioritized objectives of CASTNet. In addition, Appendix A contains illustrative examples of showing how monitoring site locations could be prioritized.

As the EPA continues to operate the CASTNet monitoring network, in partnership with other Agencies and Departments, the SAB encourages the Agency to address the concerns raised in the enclosed report and consider the advice and recommendations. The SAB appreciates this opportunity to review the CASTNet rural ambient air monitoring network and looks forward to the EPA's response to these recommendations.

Sincerely,

Chair
EPA Science Advisory Board

Chair
SAB CASTNet Review Panel

NOTICE

This report has been written as part of the activities of the EPA Science Advisory Board, a public advisory committee providing extramural science supporting EPA decisions and advice to the Administrator and other officials of the Environmental Protection Agency. The Board is structured to provide a balanced, expert assessment of scientific matters related to problems facing the Agency. This report has not been reviewed for approval by the Agency and, hence, the contents of this report do not represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the Federal government, nor does mention of trade names or commercial products constitute a recommendation for use. Reports of the EPA Science Advisory Board are posted on the EPA website at https://sab.epa.gov.

The SAB is a chartered federal advisory committee, operating under the Federal Advisory Committee Act (FACA; 5 U.S.C., App. 10). The committee provides advice to the Administrator of the U.S. Environmental Protection Agency on the scientific and technical underpinnings of the EPA's decisions. The findings and recommendations of the Committee do not represent the views of the Agency, and this document does not represent information approved or disseminated by EPA.

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Dr. Olivia Clifton, Associate Research Scientist, Center for Climate Systems Research, Columbia University, and NASA Goddard Institute for Space Studies, New York, NY.

Mr. Dirk Felton, Research Scientist, Environmental Conservation, New York State, New York Department of Environmental Conservation, Albany, NY

Dr. John Graham, Senior Scientist, Clean Air Task Force, San Rafael, CA

Director Lisa Lone Fight, Director, Science, Technology, and Research Department, MHA Nation, Three Affiliated Tribes, New Town, ND

Mr. Arie Manangan, Health Scientist, Centers for Disease Control (CDC), Atlanta, GA

Dr. Huiting Mao, Professor, Chemistry, State University of New York College of Environmental Science and Forestry, Syracuse, NY

Dr. Sarah J. Nelson, Director of Research, Appalachian Mountain Club, Gorham, NH

Dr. Nga Lee Ng, Love Family Professor, School of Chemical and Biomolecular Engineering and School of Earth & Atmospheric Sciences, Georgia Institute of Technology, Georgia Institute of Technology, Atlanta, GA

Dr. Gabriele Pfister, Senior Scientist, Atmospheric Chemistry Observations and Modeling Lab, NCAR Boulder CO, University Corporation for Atmospheric Research, University Corporation for Atmospheric Research (UCAR), Boulder, CO

Ms. Katie Praedel, Air Monitoring Section Chief, Wisconsin Department of Natural Resources, State of Wisconsin, Madison, WI

Dr. Stephanie Shaw, Technical Executive, Electric Power Research Institute (EPRI), Palo Alto, CA

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Dr. Rebecca Fry, Professor, Department of Environmental Sciences and Engineering, School of Global Public Health, University of North Carolina, Chapel Hill, Chapel Hill, NC

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Dr. Steven P. Hamburg, Chief Scientist, Environmental Defense Fund, Providence, RI

Dr. Selene Hernandez-Ruiz, Director, Laboratory and Analytical Services Division, Water Resources Mission Area, U.S. Geological Survey, Lakewood, CO

Dr. Elena G. Irwin, Distinguished Professor of Food, Agricultural and Environmental Sciences in Economics and Sustainability and Faculty Director for the Sustainability Institute, Department of Agricultural, Environmental, and Development Economics, The Ohio State University, Columbus, OH

Dr. David Keiser, Professor, Department of Resource Economics, University of Massachusetts Amherst, Amherst, MA

Dr. Mark W. LeChevallier, Principal, Dr. Water Consulting, LLC, Morrison, CO

Dr. Angela M. Leung, Clinical Associate Professor of Medicine, Department of Medicine, Division of Endocrinology, Diabetes, and Metabolism, David Geffen School of Medicine; VA Greater Los Angeles Healthcare System, University of California Los Angeles, Los Angeles, CA

Director Lisa Lone Fight, Director, Science, Technology, and Research Department, MHA Nation, Three Affiliated Tribes, New Town, ND

Dr. Lala Ma, Associate Professor, Department of Economics, Gatton College of Business and Economics, University of Kentucky, Lexington, KY

Dr. Enid Neptune, Associate Professor of Medicine, Department of Medicine, Division of Pulmonary and Critical Care Medicine, Johns Hopkins University, Baltimore, MD

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Dr. Austin Omer, Sustainable Systems Agronomist, Crop Science Commercial, Bayer U.S., Morton, IL

Dr. Gloria Post, Research Scientist, Division of Science and Research, New Jersey Department of Environmental Protection, Trenton, NJ

Dr. Amanda D. Rodewald, Garvin Professor and Senior Director of Center for Avian Population Studies, Department of Natural Resources and the Environment, Cornell Lab of Ornithology, Cornell University, Ithaca, NY

Dr. Jonathan M. Samet, Professor, Departments of Epidemiology and Environmental and Occupational Health, Colorado School of Public Health, Aurora, CO

Dr. Elizabeth A. (Lianne) Sheppard, Rohm and Haas Professor in Public Health Sciences, Department of Environmental & Occupational Health Sciences and Department of Biostatistics, Hans Rosling Center for Population Health, University of Washington, Seattle, WA

Dr. Drew Shindell, Nicholas Distinguished Professor of Earth Science, Duke Global Health Initiative, Nicholas School of the Environment, Duke University, Durham, NC

Dr. Genee Smith, Assistant Professor, Department of Environmental Health and Engineering, Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD

Dr. Daniel O. Stram, Professor, Department of Population and Public Health Sciences, Keck School of Medicine, University of Southern California, Los Angeles, CA

Dr. Peter S. Thorne, University of Iowa Distinguished Chair and Professor, Department of Occupational & Environmental Health, College of Public Health, Director of Human Toxicology Program, University of Iowa, Iowa City, IA

Dr. Godfrey Arinze Uzochukwu, Senior Professor, Waste Management Institute, North Carolina Agricultural and Technical State University, Greensboro, NC

Dr. Dominique van der Mensbrugghe, Research Professor and Director of the Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University, West Lafayette, IN

Dr. Wei-Hsung Wang, Professor, Center for Energy Studies and Director of the Radiation Safety Office, Louisiana State University, Baton Rouge, LA

Dr. June Weintraub, Deputy Director, Center for Environmental Health, California Department of Public Health, Sacramento, CA

Dr. Sacoby Wilson, Professor and Director of the Center for Community Engagement, Environmental Justice, and Health (CEEJH), Maryland Institute for Applied Environmental Health, School of Public Health, University of Maryland-College Park, College Park, MD

Dr. Douglas Wolf, Senior Fellow, Syngenta Crop Protection LLC, Greensboro, NC

Dr. Yiliang Zhu, Professor, Division of Epidemiology, Biostatistics, and Preventive Medicine Department of Internal Medicine, School of Medicine, University of New Mexico, Albuquerque, NM

SCIENCE ADVISORY BOARD STAFF

Dr. Thomas Armitage, Designated Federal Officer, U.S. Environmental Protection Agency, Science Advisory Board Staff Office, Washington, DC

Review of the Clean Air Status and Trends Ambient Air Monitoring Network (CASTNet)

January 31, 2024

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

AGU	American Geophysical Union
AMoN	Ammonia Monitoring Network
AQS	Air Quality System
ASCENT	Atmospheric Science and Chemistry mEasurement NeTwork
BIPOC	Black, Indigenous and People of Color
BLM	Bureau of Land Management
CAMD	Clean Air Markets Division
CAMx	Comprehensive Air Quality Model with Extensions
CASTNet	Clean Air Status and Trends Network
CLAD	Critical Loads of Atmospheric Deposition Science Committee
CMAQ	Community Multiscale Air Quality Model
CMAS	Community Modeling and Analysis System Center
DV	Design Value
EPA	United States Environmental Protection Agency
FACA	Federal Advisory Committee Act
Geos-CHEM	3D atmospheric chemistry and transport model
Hg	Mercury
MDN	Mercury Deposition Network
NAAQS	National Ambient Air Quality Standards
NADP	National Acid Deposition Program
NPS	National Park Service
NO_x	Oxides of Nitrogen
NTN	National Trends Network
OAQPS	Office of Air Quality Planning and Standards
OAR	Office of Air and Radiation
ORD	Office of Research and Development
O3, O_3	Ozone
PFAS	per- and polyfluorinated and per-and polyfluoroalkyl substances
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Project Plan
SAB	Science Advisory Board
SES	Socio-Economic Status
SIP	State Implementation Plan
SO_x	Oxides of Sulfur
STAR	Status of Tribal Air Report to Tribal Nations
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter with aerodynamic diameter less than or equal to 2.5 Micrometers
SLAMS	State and Local Air Monitoring Stations

1. INTRODUCTION

The U.S. Environmental Protection Agency's (EPA) Office of Air and Radiation (OAR) requested the EPA Science Advisory Board (SAB) review the Clean Air Status and Trends Network (CASTNet) and provide advice on the future operations and mission of the network. CASTNet is a rural air monitoring network that provides information on air pollution trends in national parks and other Federal lands and rural State and Tribal lands. EPA launched CASTNet more than 30 years ago in response to the passage of the Clean Air Act Amendments of 1990. The network has provided consistent, national-scale data on nitrogen and sulfur deposition (including acid rain), ozone air pollution, fine particle concentrations of nitrogen and sulfur species and their gaseous precursors, as well as mercury deposition and ammonia.

The SAB Staff Office formed the CASTNet Review Panel composed of nationally and internationally recognized scientists with demonstrated expertise in the following disciplines: Atmospheric Sciences; Air Quality Monitoring; Atmospheric Modeling; Atmospheric Chemistry; Ecology; Geostatistics; Biogeochemical Cycling; and Climate Change. The panel included experience with gaseous and particle wet and dry deposition; ozone and nitrogen impacts on ecosystems; critical loads; climate change impacts on air quality; differences in rural and urban air quality; photochemistry; atmospheric ammonia measurements, modeling and emission inventories; analysis of long-term environmental trends; forest ecology; soil chemistry; stream and lake chemistry; and biological monitoring of acid sensitive species. The Panel held its first public deliberations in a face-to-face meeting May 24th to the 26th, 2023 and a videoconference on October 11, 2023.

The Clean Air Status and Trends Network (CASTNet) is a national long-term monitoring network that provides data to characterize air pollutant concentrations in rural communities, estimate the deposition of air pollutants and quantify their ecological effects, and assess the effectiveness of the Agency's regulatory programs (e.g., as related to air quality and deposition trends). The CASTNet Review Panel conducted the review of CASTNet with public deliberations held May 24 to 26th, 2023.

CASTNet measurements were initially designed, and are currently used, to evaluate trends in near-surface atmospheric composition and the effectiveness of regional and national air pollution control programs. Over the last 15 years, CASTNet measurements have also been used to review, set, and assess compliance with the primary and secondary NAAQS (i.e., O_3, PM, SO_x, NO_x); support scientific advances in understanding the fate and regional transport of ozone and $PM_{2.5}$ and precursors, including the impact of climate change on air pollution; and underpin the development, evaluation, and application of chemical transport models used by the Agency and researchers worldwide to establish effective regulations and enhance our ability to estimate air pollution in regions without air pollution monitoring into the future.

CASTNet, as a rural monitoring network, is unique from and complementary to, state regulatory measurements (e.g., the State or Local Air Monitoring Stations, denoted as SLAMS) that are typically located within urban population centers. CASTNet is managed and operated in cooperation with the National Park Service (NPS), Bureau of Land Management (BLM), and other partners, including federal, state, and local agencies, and seven Native American tribes. The CASTNet program of EPA OAR is a major contributor to the National Atmospheric Deposition Program (NADP), a long-term cooperative environmental monitoring effort of federal, state, and tribal agencies, educational institutions, non-governmental organizations, and private companies. These programs monitor atmospheric concentrations and deposition of pollutants and their effects on ecosystems. NADP consists of more than 250 sites across North America, including the National Trends Network (NTN), which monitors precipitation chemistry, the Mercury Deposition Network (MDN), which monitors mercury in precipitation and dry deposition, and the Ammonia Monitoring Network (AMoN), which monitors ambient ammonia concentrations. EPA OAR supports 28 NTN sites, and 61 AMoN sites, and hosts other networks equipment and operations such as MDN. Many of the CASTNet and NADP/NTN sites have been operating for more than 30 years.

Currently CASTNet emphasizes national-scale coverage, methodological consistency, and long-term monitoring at rural sites with infrastructure investments in power, communications, and partnerships. As such, any proposed adjustment to CASTNet should value this unique set of characteristics. Generally, any proposed adjustment should prioritize multipollutant measurements that inform issues impacting rural areas and the national scale, including the transport and chemical transformation of pollutants, and chemical transport and total deposition models, as CASTNet currently does.

The current configuration of CASTNet informs understanding of air pollution dynamics (e.g., long range transport) as well as temporal trends and variations in air pollutants not only over the rural regions sampled, but also at the national scale and urban and suburban regions. The SAB also emphasizes that the current configuration of CASTNet promotes understanding of links between air pollution and meteorology and detecting the signal of climate change influences on air quality, which requires multidecadal records produced with methodologically consistent data. Uncovering the influences of meteorology and detecting the climate change signal also require sampling at more rural and regionally representative areas that sample ‘background air’, as CASTNet does, because urban and suburban sites are very strongly influenced by local changes in anthropogenic precursor emissions. Overall, CASTNet is a unique network that in its current configuration is well designed and sited to provide long-term, stable site infrastructure for tracking national and regional scale background air pollution and climate change influences on air quality.

Given the variety of uses of the CASTNet data, the SAB recommends no suspension or operational reductions to the existing network. However, the SAB understands the limitations of shifting budgets and priorities. To allow EPA to be adaptive to changing priorities and funding, the SAB offers metrics for strategizing possible network uses, objectives, and long-term goals. These metrics should be used by EPA to determine synergies across objectives and weigh potential data losses and continuity breaks when the prioritization of sites and quantities measured are being considered in the face of budget cuts (see Appendix A.)

In summary, CASTNet as configured over the previous decade, with some measurement locations extending back more than thirty years, has provided a valuable resource that could reliably support EPA in meeting many of its current and future priority goals.

This report is organized by charge question and includes an Appendix A that orients the responses around key considerations. Each section includes one of the six charge questions followed by the SAB's consensus response and recommendations. The recommendations are grouped into three tiers to indicate their priority. We offer Tier 1 recommendations as our highest priority; Tier 2 recommendations to strengthen the science over time; and Tier 3 recommendations to be pursued further in the future as resources allow.

All materials and comments related to this report are available at the SAB website http://sab.epa.gov under the CASTNet review project.

2. RESPONSE TO CHARGE QUESTIONS

2.1. Charge Question 1: How Well Have Past and Current Objectives Been Met?

Charge Question 1. Please provide your opinion on past and present CASTNet efforts to meet current scientific and policy-relevant monitoring objectives. The panel should provide perspectives on the program's ability to:

a. Provide high quality data on ambient concentrations of sulfur and nitrogen species, rural ground-level ozone, and other forms of atmospheric pollution

b. Monitor, assess, and report on geographic patterns and long-term temporal trends in air concentrations and atmospheric deposition of pollutions

c. Serve as a platform for air quality and deposition research, and ecological assessments

d. Provide data to evaluate, validate, and improve atmospheric chemical transport and deposition models

e. Support the implementation of, and compliance with, the National Ambient Air Quality Standards (NAAQS) for ozone, NOx, SO2, and PM2.5

The SAB concludes that EPA has been successful in achieving these four principal objectives of the CASTNet program, which are to: (1) provide high quality data on atmospheric concentrations and deposition of sulfur and nitrogen species, rural ground level ozone, and other forms of atmospheric pollution, (2) monitor, assess, and report on geographic patterns and long-term temporal trends in ambient air concentrations and atmospheric deposition of air pollutants, (3) serve as a platform for air quality and deposition research, and ecological assessments, and (4) validate and improve atmospheric chemical transport and deposition models. The SAB recommends changes for CASTNet to address shortcomings in achieving Agency goals for measuring and reporting $PM_{2.5}$. Detailed comments follow in report sections 2.1.1 to 2.1.5.

Below are recommendations and suggestions structured to provide constructive feedback to assist with future planning, establishment of priorities, and modernization.

The following recommendations are noted:

Tier 1

- Continue to monitor atmospheric concentrations of SO_2, SO_4, HNO_3, NO_3, NH_4 and O_3
- Replace the current generation of ozone monitors with newly purchased and updated monitors.
- Maintain filter pack sampling at as many long-term sites as possible prioritizing long-term research sites where multiple measurements occur, or other measurement programs are co-located (such as ASCENT, Atmospheric Science and Chemistry mEasurement NeTwork, https://ascent.research.gatech.edu).
- Better integrate and increase visibility of CASTNet measurements and operations with other U.S. federal, state and local air quality monitoring networks, both inside and outside of EPA

- Prioritize continuation of sample and filter archiving. Goal should be to maintain the archive period for as long as possible for current locations, with current methods, for consistency toward the goal to maintain long-term trends.
- Close the geographic gap in CASTNet sites for ozone measurements in the central US (e.g., North Dakota to Texas). Note that this should be done after or concurrent with the replacement of the current generation of ozone monitors.

Tier 2

- Consider switching from weekly to biweekly filter pack sampling as an alternative to site reductions.
- Consider deploying AMoN sites to close the gap in coverage across the central US (e.g., North Dakota to Texas), especially where there are agricultural influences.
- Add measurements of important model-simulated air quality constituents (such as hourly NO_2 and HCHO in summer) at a limited number of sites, especially if inexpensive methods become available and can be easily adapted to the network.
- Add $PM_{2.5}$ measurements in limited locations, prioritizing continuous monitoring methods, especially in areas downwind of, and impacted by, wildfire.
- Consider more formal engagement with the atmospheric modeling community (CMAQ, CAMx, GEOS-Chem, MUSICA, in particular) such as discussions of monitoring needs, gaps, etc. This could occur at a modeling-specific meeting such as the CMAS Center meeting or at a symposium held at a larger conference such as AGU, AMS, or another.

Tier 3

- Consider returning integrated, collocated, meteorological data such as temperature, dew point, wind speed and direction, precipitation, etc. into the CASTNet measurement suite, at least at a few critical locations.
- Strengthen linkage with satellite observations (e.g., TEMPO) for monitoring ozone air pollution and precursors.
- Use CASTNet as locations for other types of air quality measurements such as, PFAS, and other constituents of PM2.5

2.1.1. Provide high quality data on ambient concentrations of sulfur and nitrogen species, rural ground level ozone, and other forms of atmospheric pollution.

The SAB concludes that CASTNet collects and reports high quality data, provides informative and detailed quality assessment (QA) documentation such as updated QAPP, current and past data quality reports, and lab intercomparisons.

The SAB highlights that CASTNet is the only network in the US that provides the process-level data to understand atmospheric chemical cycles of atmospheric sulfur and nitrogen. The network provides unique data, in which both gas and particulate species are measured, as well as the loss of the species via wet deposition. Such data have substantially advanced air quality, atmospheric chemistry, and deposition research, and our understanding of the ecological effects associated with air pollution and deposition of nitrogen and sulfur to aquatic and terrestrial ecosystems.

The SAB offers a method for prioritizing network changes in Appendix A. Assigning scores and weights allows for cross objective analysis of competing priorities and ranking investments. Toward this end, in the absence of a thorough application of the suggested methods of Appendix A, the SAB supports continued collection of hourly ozone data and suggests that EPA consider replacing the current generation of ozone monitors with newly purchased and updated monitors. The SAB also concludes that weekly sampling of the filter packs is adequate to meet program goals, however, if budget constraints increase, the SAB would prioritize exploring and considering the possibility of biweekly filter pack sampling (weekly sample collected every other week) but proceed at specific sites only if data quality would not be compromised. An important consideration is that CASTNet is the only air quality monitoring network that provides the process-level data needed to understand atmospheric sulfur and nitrogen cycles, in which both gas and particulate species are measured, as well as their loss via wet deposition.

2.1.2. Monitor, assess, and report on geographic patterns and long-term temporal trends in air concentrations and atmospheric deposition of pollutants.

The geographic coverage represented by CASTNet sites is particularly important because the network primarily includes rural locations for which air quality monitoring is often otherwise sparse due to low population density and lack of resources. Rural network monitoring sites are crucial for building scientific understanding of local, regional, and long-range impacts from agricultural activities (which are sources of NH_3, NOx, VOC), chemical transformation of pollutants from upwind urban sources, fossil fuel extraction, and wildfires, among other air pollutant sources. In addition, loss of rural monitoring sites may enhance pre-existing biases in exposure assessments of ecosystems and humans living in those regions, including tribal and other disadvantaged communities. Finally, rural sites provide important data that can be used as upwind or downwind comparison points to larger urban/suburban and/or industrialized areas to assist with the interpretation of long-range transport and evolution of air plumes, as well as separating the local vs. background contributions.

The SAB concludes that EPA well meets its goals of describing spatial and temporal patterns and trends of air pollutants: (1) by providing annual color-coded nationwide maps that provide concentrations for up to seven air pollutants, (2) through contributions to the similar NADP maps of wet deposition, and (3) by contributing to Clean Air Markets Division (CAMD) reports that include quantitative temporal trend analyses. By making CASTNet data publicly available, access and analyses by investigators outside of EPA continues to be facilitated as reflected by the many papers and reports that have provided temporal and spatial analyses based on CASTNet data. The need for consistency in site locations and methods of a network designed for long-term trend detection and quantification cannot be overemphasized. Careful consideration before re-locating sites or changing methods is recommended (see Appendix A).

Currently, there is a geographic gap in CASTNet sites in the central US (e.g., the region spanning from North Dakota to Texas). EPA should consider closing this gap if re-evaluation of the network occurs, or if funds are available to expand at least ozone monitors to Tribal lands. Some of this area has high agricultural emissions, while other parts of this area reflect regional background air that could aid interpretation of data from more urban and suburban locations. The SAB recommends consideration of addressing this geographic gap by deploying instrumentation for ozone and ammonia/ammonium (the latter in areas of high agricultural emissions). NOx is another constituent that could be considered for measurement in this gap area.

Regarding the CASTNet contribution to broader geographic coverage of air pollutant concentrations and deposition across the US, the SAB recommends that EPA take a more wholistic approach by examining how the CASTNet sites fit relative to other networks such as SLAMS and those of agencies such as the NPS, as well as the new advanced aerosol measurement network ASCENT. Engagement across all air monitoring agencies and departments could support a comprehensive monitoring strategy that optimizes against multiple objectives. CASTNet meets objectives for long term rural ambient air monitoring for acid deposition and has grown to provide critical data for atmospheric chemistry and long-range transport for model formulation and evaluation. Coordination will enhance this function and provide better observational evidence of climate change impacts on air quality, improved understanding of atmospheric chemistry and other policy and scientific needs. Better integration and coordination with these other networks can inform decisions when faced with a need to close sites due to inadequate funding. One example of this integration is the AirNow program. CASTNet sites provide a benefit to the public by providing ozone data every hour to AirNow from rural locations that otherwise would not have access to this information.

Finally, the SAB notes that ozone dry deposition is not currently measured, which is a clear discrepancy in CASTNet's ability to monitor, assess, and report on geographic patterns and long-term temporal trends in atmospheric deposition of pollutants, given that ozone injures plants after dry deposition through plant stomata, and this impacts resources and carbon and water cycling substantially (see review by Clifton et al., 2020). Adding calculated ozone deposition to the list of provided data would enhance the value of CASTNet data.

2.1.3. Serve as a platform for air quality and deposition research, and ecological assessment.

The SAB believes that EPA is doing an excellent job with promotion of CASTNet data and site locations as the basis for air quality research and ecological assessments; however, site discontinuations and suspensions in 2022 interrupted the work of some researchers. Many public commenters at the meeting of this SAB review provided evidence of the value of the CASTNet data and the disruption and losses even temporary interruptions incurs to them, their organizations, and the public (as particularly noted by representatives from the Adirondack Council and National Park Service.) A recent search using the Google Scholar platform and the key words EPA, CASTNet, air quality, and ecosystem yielded 678 publications during the years 2018 to 2023 which demonstrates the value of these data to investigators. The bibliography that EPA maintains on the CASTNet web site (CASTNet Bibliography | EPA) includes 1,278 entries dating back to 1990. Maintaining a bibliography of network-based publications is an excellent practice that is valuable to those who study air quality and is recommended base practice for any environmental monitoring network. CASTNet already provides Digital Object Identifiers (DOI) for its datasets; the network should more proactively encourage users to use DOIs, with the aim of using these DOIs to generate bibliographies automatically.

A recent example of the scientific benefit of allowing and encouraging the use of CASTNet sites as a platform for research and new measurements is exemplified by sites where PFAS concentrations in atmospheric deposition are currently being measured. The SAB strongly recommends that EPA continue to encourage the use of CASTNet sites as locations for other types of air quality measurements.

Strong evidence of the value of CASTNet as a platform for air quality and deposition research and ecological assessment can be seen by examining the work of the NADP Critical Loads of Atmospheric Deposition Science Committee (CLAD). CLAD seeks to better understand the role of air pollutant deposition in affecting ecosystems by examining thresholds of deposition above which ecosystem harm is evident ("critical loads"). The CLAD web pages (Critical Loads of Atmospheric Deposition Science Committee, 2023) include critical loads data, maps, and publications that demonstrate the scientific and policy-informing value of the work of this multi-agency committee that relies in part on CASTNet data. The CASTNet is the only network that measures concentrations of constituents such as SO_2 and NH_4 in rural locations and is thus a source of unique data needed in critical loads assessments.

Long-term archiving of filter packs and precipitation samples is an important component of CASTNet in supporting air quality and ecosystem research and assessment. Investigators use these archived materials to make novel measurements of constituents that were not among the list of analytes with respect to standard sample processing. These analyses of specialized constituents such as isotope and organic species have provided new scientific insight to air quality investigations (for example, Elliott *et al.,* 2009). The ability to perform new measurements on archived samples will become even more valuable as the need to understand components of wildfire smoke, and how it is changing, becomes more urgent. The SAB strongly encourages the continuation of the policy of archiving samples and filter packs for as long as is feasible.

2.1.4. Provide data to evaluate, validate, and improve atmospheric chemical transport and deposition models.

Air pollution at any given location is a function of transport to and from a location (and thus remote emissions), deposition, atmospheric chemistry, and local emissions. Atmospheric modeling is key for building scientific understanding of air pollution and its sources and sinks, and the subsequent informing of air quality policies. Understanding the value of model simulations relies on observational datasets with which the simulations can be evaluated, and CASTNet data are important in this regard. The long-term data are particularly valuable in evaluating and improving models for more accurate predictions of seasonal and annual changes. These models are advanced and improved over time when analyses of observational data, such as that from CASTNet, lead to the identification of missing or poorly formulated model processes.

One example of the critical role CASTNet data provide in the scientific, and ultimately policy contexts, involves CASTNet ozone data and chemical transport modeling. CASTNet ozone data indicate regionally representative ozone concentrations, which are used to evaluate and improve atmospheric models (which typically have coarse spatial resolution, on the order of tens to hundreds of kilometers), and in turn these models are used to estimate policy-relevant background ozone (Reidmiller et al, 2009; Fiore et al., 2014; Lin et al., 2017; Jaffe et al., 2018). Given the many uncertainties in sources and sinks of air pollutants and their precursors, the more long-term, consistent data that are available (such as provided by CASTNet), the better our understanding of the contribution of background ozone to ozone air pollution across the US.

The SAB noted that some atmospheric species such as N_2O_5 and organic nitrogen must be simulated by models such as CMAQ because routine measurements of these species do not exist. The EPA should consider including measurements of important model-simulated air quality constituents, especially if inexpensive methods become available and can be easily adapted to the network.

Finally, the SAB recommends that CASTNet continue to engage with the atmospheric modeling community (CMAQ, CAMx, GEOS-Chem (https://geos-chem.seas.harvard.edu), MUSICA (https://www2.acom.ucar.edu/sections/multi-scale-infrastructure-chemistry-modeling-musica) in particular) to provide the data needed to advance and improve model formulations.

2.1.5. Support the implementation of, and compliance with, the National Ambient Air Quality Standards (NAAQS) for ozone, NOx, SO_2, and $PM_{2.5}$.

CASTNet data are a fundamental component of NAAQS development, implementation, and assessments for ozone, NO_x, SO_2 and $PM_{2.5}$. It is noteworthy that CASTNet data have become an important contributor to primary and secondary NAAQS development, implementation, and assessment. For example, the most recent Integrated Science Assessment report prepared to support the current evaluation of nitrogen dioxide and sulfur dioxide secondary standards (EPA, 2023). The CASAC that provided recommendations to EPA as part of the most recent review of the NAAQS secondary standards for NOx, SOx and PM stated that without the data provided by CASTNet and other monitoring networks, there would be "no scientific basis for establishing new standards". The committee in their letter to the EPA Administrator Regan recommended that EPA prioritize funding for CASTNet monitoring data because they are "critical to our understanding and protection of people, underserved communities, and ecosystems during a period of changing climate."

As air quality standards change over time, geographic site coverage, instrumentation, and methods should be periodically considered for change and adaptation to maintain the importance of CASTNet data to inform policies such as the implementation and compliance with the NAAQS. An objective approach to assist decisions when sites are being considered for termination is to examine the loss of model predictive power (accuracy and precision) when data from the site under consideration is removed.

The SAB recommends that EPA consider the value of additional measurement of $PM_{2.5}$ at all CASTNet sites, in particular continuous measurements. Another more flexible option is installation of continuous $PM_{2.5}$ monitors at a limited number of sites that have been frequently impacted by wildfire smoke in recent years. The SAB offers this as a lower priority suggestion. Nonetheless, this topic is currently of considerable interest and will likely only increase in importance in the future because of expanding patterns of wildfire smoke impacts on human health across the US (e.g., Childs *et al.,* 2022; Iglesias *et al.,* 2022.).

The following recommendations are noted:
Tier 1

- Prioritize CASTNet sites where other types of air quality measurements are co-located (such as NADP/NTN, rural NCore, and IMPROVE). CASTNet is a unique air monitoring network in its prioritization of rural siting and national spatial distribution driven by network objectives, absent of population metrics. Additionally, established CASTNet sites offer readily accessible electrical power, internet connections, and a known air monitoring site platform that meets EPA regulatory siting Criteria outlined in 40 CFR Part 58. These qualities make CASTNet a valuable platform for considering the addition of new measurements, especially for those measurements tracking climate change impacts on air quality.
- Prioritize network changes according to Appendix A. Assigning scores and weights allows for objective analysis of competing priorities and ranking investments. The SAB indicates the Agency must develop and apply a method along these lines for considering network changes in the future.
- Consider biweekly filter pack sampling (weekly sample collected every other week) but proceed to biweekly at specific sites only if data quality would not be compromised.
- Provide concentrations in units consistent with regulatory measurements. Specifically, Parts Per Billion (PPB) and $\mu g/m^3$.
- Maintain a bibliography of network-based publications
- Continue to use CASTNet sites as locations for other types of air quality measurements.
- Continue archiving samples and filter packs for as long as is feasible and making samples available for new analyses.

- Replace the current generation of ozone monitors with newly purchased and updated monitors.
- Close the geographic gap in ozone in the central US (e.g., the area spanning North Dakota to Texas).

Tier 2

- Close the geographic gap in ammonia, ammonium, and nitrogen oxides in the central US (e.g., the area spanning North Dakota to Texas), especially where there are agricultural influences

Tier 3

- Add ozone deposition to the list of provided data from CASTNet.

2.2. Charge Question 2: Do Proposed Approaches Meet the Goals of EPA's Strategic Plan?

Charge Question 2: The Agency recently finalized the FY22 – FY26 Strategic Plan. In relation to the Plan's Objectives and Long-Term Performance Goals (e.g., Objective 4.1: Improve Air Quality and Reduce Localized Pollution and Health Impacts) please provide insight regarding the Agency's ability to meet the Plan's Objectives and Long-Term Performance Goals under the presented network approaches.

Lovett et al., (2007) asked, "Can today's monitoring programs answer tomorrow's questions?" They argue that an effective and enduring monitoring program measures key variables determined from a comprehensive understanding of our dynamic environment. Additionally, they claim the costs of monitoring are small when compared to their scientific value that informs policy to protect the environment. That provides a cornerstone piece to justify continued operation of CASTNet, given the objectives satisfied by its measurements.

Here we are asked to assess the extent to which CASTNet, established three decades ago, primarily to meet the needs of the Acid Rain Program, can meet EPA's current objectives and goals. CASTNet was designed to assess the effectiveness of emission control programs by determining spatial patterns and temporal trends in ambient concentrations and deposition of sulfur and nitrogen (Edgerton et al., 1992; Baumgardner et al., 1999, 2002). EPA has expanded CASTNet's objectives to address current and emerging needs to help the Agency meet its ongoing priorities (see Appendix A). The report entitled "Clean Air Status & Trends Network (CASTNet) Background and Configuration Approaches" summarizes the current uses of CASTNet as follows: "…to review, set, and assess compliance with the primary and secondary NAAQS (i.e., O_3, PM, SOx, NOx); support scientific advances in understanding the fate and regional transport of ozone and $PM_{2.5}$ precursors, including evaluating the impact of climate change on air pollution; and underpin the development, evaluation, and application of air quality models used by the EPA to establish effective regulations." (EPA, 2023).

Two priorities are clear in the EPA strategic plan: climate change and environmental justice. The past two decades of scientific research demonstrates the importance of considering changing climate into its air quality management and public health risks (Garcia-Menendez et al., 2015, 2017; Tagaris et al., 2009, Nassikas et al., 2020; Bell et al., 2007; Clifton et al., 2014; Pfister et al., 2014; Fiore et al., 2015) as well as environmental justice (Donaghy et al., 2023) in the last few years. CASTNet, as currently configured, can meet many of the current strategic plan's goals and objectives, but substantial reductions in data collection, as put forth in the background materials, would degrade the network's utility and interrupt long-term records that are foundational to our current understanding of spatial and temporal air quality patterns and issues, especially as relevant for climate change and environmental justice.

The SAB developed a table as a visual and organizational aid to link CASTNet's objectives with the goals of the strategic plan (Appendix A; Table 1). This table shows how the major objectives align well with the strategic goals of tackling the climate crisis and ensuring clean air, while contributing to the goals of enforcing laws, ensuring compliance and advancing environmental justice.

The most obvious correspondence between the strategic plan and CASTNet measurements is referenced in the question put forth by EPA: Goal 4: Ensure Clean and Healthy Air for All Communities: Objective 4.1: Improve Air Quality and Reduce Localized Pollution and Health Impacts. Specific strategic plan goals that CASTNet data would help inform are to improve measured air quality in counties not meeting the current National Ambient Air Quality Standards (NAAQS) from the 2016 baseline by 10% and strive to ensure all people with low socio-economic status (SES) live in areas where the air quality meets the current fine particle pollution (PM2.5) NAAQS by September 2026.

For example, for the first goal listed, based on 2014-16 design values (DVs) there were a handful of CASTNet locations that failed to meet the ozone NAAQS, and a couple additional CASTNet locations that started collecting data after that baseline also exceed the current ozone NAAQS. From the baseline period to 2020-22, about twice as many CASTNet locations had a reduction in DV than sites that observed an increase. About 15% of locations had no change in peak ozone. These near-term trends in ozone data from CASTNet would clearly show if the agency's mandated reduction goals for ozone have been met in 2026 at CASTNet sites so long as the ozone monitors continue to operate. Reconsideration of the ozone standard could substantially move the goal post for attainment, with the draft CASAC recommendation revision to the primary standard placing the majority to virtually all CASTNet locations into nonattainment at the upper and lower end of the recommended range (60 to 55 ppb).

Since CASTNet measures particulates without size distinction, the data cannot fully assure compliance with the fine particle standard in rural SES areas (see Sickles and Shadwick, 2008). Nonetheless, the data combined with modeled results of other constituents would confirm the relative importance of the inorganic component of the aerosol. The measurements do provide evidence useful to SIP planners as they assess the relative importance of local versus transported pollution. Based upon panelists' evaluation of the Climate and Economic Justice Screening Tool data (CEQ 2023), only 2% of census tracts had $PM_{2.5}$ levels exceeding the current annual standard, and were also located in low-income communities identified as disadvantaged. Presumably these high $PM_{2.5}$ tracts are predominantly in higher population areas not monitored by CASTNet.

The second strategic plan goal where CASTNet data are critical relates to tackling climate change. The plan highlights EPA's role in assisting the nation to anticipate, prepare for, and adapt to or recover from the impacts of climate change. Recent years have seen an increase in wildfires that inundate wide swathes of the country under clouds of smoke, particles, and other pollutants (Abatzoglou et al., 2016, others) and this increase may continue (Bowman et al., 2020). CASTNet's long-term data record is particularly relevant for evaluating changes in environmental responses to climate-driven factors, which operate on long time scales relative to traditional air quality management that envisions more direct, emission control-environmental response. Although CASTNet data are useful for evaluating environmental response to climate change, current spatial coverage may miss the region of the most prevalent wildfire smoke impacts. Kaulfus et al., (2017) summarize wildfire smoke climatology and map the results, revealing the area of the country experiencing the most days of smoke corresponds to the region of the country (over the Great Plains) with the fewest air quality monitors-a pattern CASTNet shares with virtually all air quality measurement networks.

In a less direct example, evidence has documented that enrichment of both phosphorus and nitrogen contribute to harmful algal blooms (HABs) in freshwaters (e.g., Paerl et al., 2016, 2010) and oceans (e.g., Gilbert 2020), particularly coupled with climate warming. The nitrogen species monitored by CASTNet can assist in tracking the spatiotemporal variations associated with the changing climate and environmental responses thereto. Although the network was not originally envisioned as a data source to track nutrient inputs to HABs, the data could prove useful in this regard.

The third area of overlap occurs for Strategic Plan Goal 3: Enforce Environmental Laws and Ensure Compliance; Objective 3.2: Detect Violations and Promote Compliance. This aligns with the original intent of the network. The CASTNet program has helped assess compliance by evaluating multi-state pollution reduction policies including the Acid Rain Program, the NO_X SIP Call and the Cross-State Air Pollution Rule. Network effectiveness in this regard would benefit from maintaining filter pack data collection at the greatest number of sites. An alternative, preferable option to the two outlined in the background material could be to retain all locations but reduce the frequency of sample collection. The option that envisions retaining roughly half of the filter pack measurements would be more likely to provide information to successfully track compliance and success of these multistate policies than the option that reduces spatial coverage down to ten locations, which could make such determinations difficult or impossible.

Finally, the strategic goal to advance environmental justice could be addressed through fulfilling several of CASTNet's objectives as indicated in the Table (Appendix A). The current configuration of CASTNet, which provides data from mostly rural sites, provides important context for local monitoring by states, Tribes, or other community groups faced with environmental justice issues because the CASTNet data can indicate regionally representative 'background' levels of air pollutants. This information helps to distinguish the portion of local air quality that can be impacted by local emission changes, which is important context for communities in urban or fence line locations or otherwise faced with environmental justice issues. The long temporal record of CASTNet data also provides decades-long context for current air pollution levels, allowing communities to understand how changes in climate and emissions have impacted air pollution at regional scales.

Advancing environmental justice could also be addressed with CASTNet data because CASTNet currently has monitors within or proximal to census tracts at risk, as determined by the Climate and Economic Justice Screening Tool (CEQ, 2023). There are a handful of such locations with ozone levels currently exceeding the NAAQS that could garner special attention for emission reduction strategies. There could also be current CASTNet sites that are reasonably close or downwind from emerging pollution sources, especially in regions with oil and gas activities or agricultural sources. However, the suite of pollutants measured by CASTNet may not adequately characterize adverse impacts of these types of sources. We close by noting that the linkages between EJ and CASTNet may be less obvious than some of the other priorities in the Strategic plan, and the pollutants measured by CASTNet may not represent the most pressing concerns for communities with environmental justice concerns.

In summary, CASTNet as configured over the previous decade, with some measurement locations extending back thirty years, has provided a valuable resource that could reliably support EPA in meeting many of its priority goals as put forth in the strategic plan. However, the two approaches outlined in the background materials document: (1) Maintain Multipollutant Sites with Significantly Reduced Spatial Footprint and (2) Maintain Regulatory Monitoring with Significantly Reduced Deposition and Ecological Assessment Capacity would each hinder and diminish the Agency's ability to meet current and future goals.

A visualization that highlights the potential impact of shrinking the network can be found on CASTNet's website. The stark contrast between three major periods is evident (the beginning ~1990, early years 2000, recent years 2010; 2018). The maps of course have limitations in the representativeness of the data, which is dependent on factors such as the pollutant, emission patterns, local environmental variables, but a substantial reduction in the number of sites would open coverage gaps that could severely compromise EPA's ability to fully characterize long-term trends and spatial variability in remote areas that critically inform scientific understanding of environmental responses in an atmosphere in flux.

The following recommendations are noted:
Tier 1

- Use an approach, like suggested in Appendix A, to evaluate possible changes to the network's design.

While the SAB does not recommend a specific network design to address the EPA strategic goals related to climate change and environmental justice, these goals are noted with specific considerations in Appendix A. For example, if EPA determines that the objective around climate change is a top priority, then consideration of maintenance of sites long-term is critical, since climate change is most often assessed on the decadal or multi-decadal scales. We recommend that, in prioritizing objectives aligned with the responses to the other charge questions, EPA consult the table in Appendix A to evaluate where there are alignments with these Goals and other goals such as compliance and spatial coverage to maximize synergies.

- For Goal 4 (as indicated in Appendix A) related to clean air for all, the SAB recommends continuing ozone monitoring, particularly in the context of potential changes in standards as targets are assessed.

- For Goal 3 (as indicated in Appendix A), related to compliance, the SAB notes that this goal aligns with the original intent of CASTNet and as such, we recommend maintaining network status in terms of analytes already measured long-term, and maximizing spatial coverage by continuing measurements at the greatest possible number of sites.

2.3. Charge Question 3: Detailed Review of Proposed Alternative Network Plans.

Charge Question 3 Please comment on the extent to which each potential network configuration addresses scientific data needs to understand air quality and atmospheric deposition impacts on human health and ecosystems. In your opinion does the mix of sites and measurements outlined in each scenario enhance the Agency's ability to implement the Clean Air Act and protect human health and the environment?

Chapter 5 of "Clean Air Status & Trends Network (CASTNet) Background and Configuration Approaches" dated February 23, 2023 indicates two specific network configurations to consider with another section of general considerations. Section 5.1.1 discusses a configuration of multipollutant observation sites with a significantly reduced spatial footprint. Section 5.1.2 provides a description labeled as "Maintain Regulatory Monitoring with Significantly Reduced Deposition and Ecological Assessment Capacity."

The SAB does not believe either Alternative Network Plan outlined in Chapter 5 meets the Agency's mission or enhances its ability to implement the Clean Air Act. The mix of sites and measurements outlined in each scenario greatly reduces the ability, in the SAB's opinion, to protect human health and the environment because both proposed scenarios will produce large spatial gaps in observations of criteria pollutant concentrations and precursors over significant geographic areas. The gaps hinder the ability to capture extreme or exceptional events and the impacts of climate change. In the SAB's opinion, a reduction, as proposed and reviewed, will likely exacerbate the already existing uncertainties in estimates of regional budgets of pollutants and reduce available data for process understanding, and ultimately erode the scientific foundation for policymaking. Reducing network size, and thus capacity to monitor changes, undermines EPA's ability to address the strategic goal related to climate change, specifically, the ability to observe changes in environmental responses to climate change, as discussed in section 2.2, especially given that climate change and its impacts will vary in different parts of the US.

CASTNet provides a wealth of long-term scientific information monitoring air pollution and the environment (through air and rainwater samples) and currently provides data needed to assess the impacts of climate change on air pollution and environmental health. This is clearly documented in numerous studies of regional pollutant budgets, as well as pollutant inputs to ecosystems and environmental impacts (e.g., Driscoll et al., 2016, Eng et al., 2021, Likens et al., 2021, Lin et al., 2017, Cooper et al., 2012, Mao et al., 2017, McGlynn et al., 2018; Rattigan et al., 2017). Decreasing the number of sites within the CASTNet network would severely diminish the utility of the network, especially for assessing the impacts of air pollution on humans and ecosystems and changes with climate change. The suggestions from the SAB are to minimize reductions in the network while still meeting EPA's strategic plan goals and the SAB offers a recommended method for approaching these decisions in this report and Appendix A.

Sites for air quality monitoring in the U.S. are comprised of many different national networks including but not limited to; SLAMS, NCORE, IMPROVE, CASTNet, National Air Toxics Trends Stations (NATTS) and Urban Air Toxics. With the spatial reductions proposed, supplemented by the required SLAMS, it is important to consider the National Ambient Air Quality Monitoring network more wholistically and how CASTNet fits in given its defined objectives.

EPA should utilize Appendix A to re-evaluate the CASTNet network on an individual site basis, prioritizing sites that: provide long-term, stable site infrastructure and data that indicate the impacts of long-range transport and climate change and are in places where US air quality goals are not met. Such data are key for building understanding of the underlying chemical, biological, and physical processes driving changes, and thus model development. While using Appendix A, EPA should prioritize sites with the goal of improving regulatory and research tools like chemical transport models; this should be one of the highest priorities for CASTNet.

Because CASTNet sites are primarily located in rural areas, and were not originally selected to reflect tribal, overburdened, or disadvantaged communities, CASTNet's support for EPA's environmental justice goals is not readily apparent. Other air quality monitoring networks typically more directly serve large populations of disadvantaged communities (i.e., NCore, SLAMS, Near Road, source-oriented sites). However, CASTNet data indirectly supports large populations of overburdened communities by facilitating improved understanding of background pollution levels and the associated modeling. Without CASTNet there would be gaps in spatial coverage nationwide that would lead to a decreased understanding of background air (i.e., the air quality concentrations in areas removed from anthropogenic emission sources). These understandings are fundamental to understanding air quality as a whole. A wealth of research has demonstrated the large spatial extent of the impact emissions can manifest in high concentrations of pollutants, such as ozone and particulate matter, in areas far from local sources.

Three sub-questions were asked by EPA in connection to the charge question 2.3. Responses for each are presented below in sections 2.3.1 – 2.3.3.

2.3.1. Please comment on the presented approaches as they relate to building monitoring capacity for overburdened and/or tribal communities.

The strength of CASTNet is in its ability to provide long-term ambient air monitoring for rural locations, which sometimes reflects overburdened or disadvantaged communities. While CASTNet sites were not originally selected to reflect disadvantaged communities or EJ areas, the sites' ambient concentrations of pollutants and precursors can be representative of larger regions (e.g., Riedmiller et al., 2009) and thus are imperative to the research community as they aim to understand local vs. remote source impacts on the air pollution experienced by tribal communities and other EJ communities.

2.3.2. Please comment on the presented approaches as they relate to evaluating air quality and deposition impacts from extreme events and certain climate-related impacts.

Climate change is expected to affect air quality in various ways, such as altering the natural emissions of air pollutants and precursors, transport patterns, chemistry, and wet and dry deposition (Jacob and Winner, 2009; Fiore et al., 2015; Szopa et al., 2021). The literature on this topic is extensive, covering different regions and future climate and emission scenarios, as well as different air pollutants and health outcomes (e.g., Murazaki and Hess, 2006; Racherla and Adams, 2008; Barnes and Fiore, 2013; Clifton et al., 2014; Pfister et al., 2014; Gonzalez-Abraham et al., 2015; Meehl et al., 2018; Nolte et al., 2018, 2018; Shen et al., 2017; Fann et al., 2015; Madaniyazi et al., 2015; Silva et al., 2017). However, there is low confidence in the response of air pollution to climate change, given uncertainty in how key natural processes affecting air pollution will change (Szopa et al., 2021). Some other challenges limiting confident assessment include uncertainties in future climate and emission scenarios, internal climate variability, and model structural uncertainty (Pienkosz et al., 2019; Fiore et al., 2015, 2022). Continued investment in understanding of CASTNet's long-term data record is critical to narrowing key uncertainties and building understanding of the impacts of mitigation and adaptation strategies on environmental and public health. For example, removing monitors without conducting an analysis such as that suggested in Appendix A risks diminishing the ability to separate the roles of climate change and emission controls on air pollution using observational records.

One of the most studied aspects of climate impacts on air quality is the effect of temperature on ozone pollution. Temperature impacts ozone through a variety of ways (Fiore et al., 2015; Porter and Heald, 2019). One of the most important processes underlying strong observed correlations between temperature and ozone on daily to interannual timescales is similar meteorological transport of ozone and heat (Fiore et al., 2015; Barnes and Fiore, 2013; Kerr et al., 2019, 2020; Porter and Heald, 2019; Zhang et al., 2022). Several studies project that, in the absence of changes in anthropogenic precursor emissions, climate change will increase near-surface ozone concentrations in some regions, especially during summer, but there is also considerable uncertainty and variability among models and climate change scenarios (Wu et al., 2008; Clifton et al., 2014; Rieder et al., 2015; Schnell et al., 2016; Garcia Menendez et al., 2017). Long-term ozone records from rural sites are critical for building our understanding of climate impacts on ozone concentrations and subsequent understanding of, and recommendations for, regulatory control strategies. Long-term ozone records from rural sites will also be especially important if the ozone NAAQS is lowered, given that climate change may push areas out-of-attainment with the current standard (Rieder et al., 2015). Removing CASTNet monitors would not only limit the scientific community's understanding of long-term ozone trends with respect to climate change, but also reduce our ability to confidently model ozone concentrations across the US and to quantify ozone exposure in rural and tribal communities.

The time scales of extreme or exceptional events range from less than an hour (e.g., a severe storm) to years (e.g., the recent decade long drought period in California), with great variability in intensity such as the different stages of a hurricane, a dust storm, heatwave, or a wildfire episode. For example, the chemical composition of fire emissions and smoke plumes can evolve on the timescales of hours (Urbanski et al., 2009; Tomsche et al., 2023). Heatwaves which are temporally dynamic, where air temperature often builds up over time associated mostly with high pressure ridges (Wang et al., 2016; Chen et al., 2023), are the commonly known condition conducive to high O_3 and PM accumulation (e.g., Fiore et al., 2015). In addition, lag effects, associated with these multiday heat waves, can affect growing air quality degradation from day to day. Robust understanding of air quality and deposition impacts from extreme events requires multidecadal records that have multiple occurrences of extreme events of the same nature.

CASTNet's O_3, NO, and NOy measurements are hourly but its filter pack sampling is currently weekly or may occur at even less frequent intervals in the future. Even weekly sampling may mischaracterize the impact of extreme or exceptional events. High-frequency temporal resolution measurements, at least hourly, are critical for building understanding of the key chemical and physical processes determining strong temporal variations in ambient concentrations and deposition of pollutants and precursors, and validating models, including for locations that are identified to be most vulnerable to extreme and exceptional events and influenced by climate change. Care should be exercised, with application of modeling and other evaluation methods, before filter pack sampling methods or sampling frequency is altered, or eliminated, at any particular site.

The stability of the network over time is most useful in tracking the influence of climate change, but specific, targeted meteorological measurements can also aid in assessing air quality responses to climate change. Rainfall measurements may provide indicators of drought, which can degrade air quality (Wang et al., 2018; Lin et al., 2020). Other meteorological measurements could reduce uncertainties in impact assessments, especially at the longest operating sites that are particularly valuable for collocated measurements, or sites where instrument intercomparison data exists or can be developed to infer or extrapolate longer time scales or wider geographic areas.

Infrastructure to support air monitoring networks is difficult to establish, expensive to remove and relatively easy to build upon once established. CASTNet offers power and internet access, which are two of the most challenging services to acquire when establishing a rural monitoring site. CASTNet offers an essential platform and infrastructure for the rapid deployment of PM2.5 sensors in rural and tribal areas, which may be important given expected increases in wildfire smoke.

2.3.3. Please include perspectives on additional, or alternative, cost-effective monitoring technologies to consider that could modernize and enhance the efficiency of the CASTNet program.

The infrastructure is in place across the CASTNet network to implement additional, alternative, cost-effective monitoring technologies. After the network has been prioritized based on Appendix A, ozone analyzers and site shelter infrastructure need to be updated, which are old and past its usable lifespan.

CASTNet offers a platform to test and modernize air quality monitoring. Many newer technologies have been developed since the start of CASTNet, which can offer finer temporal resolution (on the order of minutes) measurements of various air pollutants (including PM components) and detailed chemical and physical properties of aerosols. For example, ASCENT is the first high-time-resolution, advanced, long-term measurement network in the U.S. for the characterization of aerosol chemical composition and physical properties (sulfate, nitrate, ammonium, chloride, organics, metals, black carbon, brown carbon, particle size, wildfire tracers etc.), utilizing modern instrumentation that is capable of real-time, long-term measurements of air pollutants. Three ASCENT sites (Joshua Tree, Yellowstone, and Great Smoky Mountains national parks) are co-located with CASTNet sites. CASTNet can leverage ASCENT infrastructure and data to enhance measurements at these sites and gain exposure to new instrumentation in air quality monitoring, while allowing for intercomparison to create a longer data record for important chemical species. Overall, modernizing the network by deploying online instruments and state-of-the-science technologies can improve data quality, capture high frequency processes, accurately monitor trace concentrations of pollutants, and enhance the efficiency of the program. Moreover, low-cost sensors would contribute to the spatial coverage of the network in keeping the public informed in a timely fashion of air quality in extreme and exceptional events. The need for low-cost sensors and modernizing the network are elaborated on in the SAB's response to Charge Question 5.

The following recommendations are noted:

Tier 1

- Utilize Appendix A to re-evaluate the CASTNet network based on site usage, prioritizing sites that: provide long-term, stable site infrastructure for process-oriented data that indicate the impacts of long-range transport of pollutants and climate change.
- Update ozone analyzers and site shelter infrastructure, after the network have been prioritized based on Appendix A

Tier 2

- Maintain filter pack network at as many long-term sites as possible prioritizing long-term research sites where multiple measurements occur, or other measurement programs that are co-located and ensure the long-term data record is maintained for inclusion in future trend analysis utilizing data sources from multiple instruments or techniques.
- Create consistency in how site measurement scales are listed in EPA's AQS.
- Consider the following table of suggestions for short term prioritization of options presented here:

Table 1: Considerations with respect to cost increases and decreases for a subset of specific options.

Objective	**Task or Method**	**Goal**	**Modification**	**Cost increase ($) decrease (-$)**
High quality ambient air measurements to inform public health	Low-cost sensor monitoring equipment	Public health awareness for wildfires	Add	$ - short term
Ecological Assessment and Environmental Protection	Filter Pack methods	Long-term data collection	Consider frequency reduction	-$
	Modernize Ozone – year round	Model improvement	Replace monitors	$ - short term
	Modernize Infrastructure	Long term trends platform	Improve aging shelter infrastructure	$$ - short term
	Re-Evaluate the Network with respect to prioritized objectives (see Appendix A)	Network cost savings and increase long term network sustainability	Remove monitors that are not useful for prioritized goals listed	-$

2.4. Charge Question 4: Additional Measurements.

Charge Question 4. For the potential approaches presented in Section 5.2, please provide comment on which data products would be the most useful to address new scientific (e.g., emerging and toxic pollutants) and policy-relevant (e.g., climate impacts on air quality, environmental justice concerns) questions. For each data product, please advise on general locations where the measurements should be made (e.g., source regions, urban/remote areas, eastern/western US), to assess air quality and ecological impacts relevant to current and potential future air quality and climate change policy questions.

Based on the information provided for this review, the SAB evaluated the six potential approaches put forward in the CASTNet Network Assignments document provided to the SAB. The SAB acknowledges that each of the options put forward would be of interest and importance to EPA's strategic plan and research to a certain extent, but recommends measurements that best complement CASTNet current capabilities, with an emphasis on promoting the network's continued operations. This is seen as a higher priority over adding new measurements that take CASTNet in a new direction due to the network's proven decades-long observational record in supporting air quality management in the US and national and international scientific research. Long-term operation and consistency should be emphasized in replacing (with appropriate overlap studies) or adding any new instrumentation or capabilities to the network. The SAB further stresses that a decision on new measurements or capabilities needs to be made in the context of other measurement and research activities of other branches in the EPA (e.g., OAQPS and ORD) as well as other agencies and programs to avoid duplication of efforts and ensure the augmentation fills a gap and addresses or meets a current need.

The SAB suggests the highest priority be the replacement or expansion of ozone monitors, given that current monitors are aging and there are already gaps in spatial coverage (e.g., the central US, in particular the region spanning North Dakota to Texas). The other options put forward are recommended to be placed at a lower priority for CASTNet. Detailed recommendations and pros and cons for the different options are provided below.

Comments Regarding Specific Approaches

2.4.1. Real-time aeroallergen concentrations measurements

Aeroallergens, which includes pollen, are of concern for human health and their impact is expected to worsen with climate change. Specifically, pollen exposure can trigger various allergic reactions, including symptoms of hay fever and can also exacerbate health conditions such as asthma and chronic obstructive pulmonary disease, or COPD. Currently, there is no nationwide aeroallergen measurement network in the US and it is clearly an unmet need for the US. An aeroallergen monitoring network would need to be designed to provide localized as well as broader information to communities and span a range of temperature, moisture, and vegetation across the US. Research on this topic could focus on developing predictive models to inform citizenry and the link between climate change and aeroallergen concentrations. Having such data and models would allow people to make better informed decisions on a daily basis to alleviate their worst symptoms. Such a network could also detect ecosystem responses to climate change (e.g., changing phenology); this is desirable to the EPA given that pollen is an EPA climate indicator.

Although pollen is a public health concern, the SAB does not see that aeroallergen monitoring is a high priority for CASTNet due to a number of concerns. While aeroallergen measurements would benefit from existing measurements (i.e., ozone, temperature, PM precursors and components) and infrastructure at CASTNet sites, the SAB does not see aeroallergen measurements informing current CASTNet data or addressing the network's primary objectives. While aeroallergen data could be used as a proxy indicator for climate change, the SAB sees that there are other non-CASTNet observations that can serve as such a metric (e.g., see NOAA National Centers for Environmental Information Climate Monitoring, 2023).

It is also not clear to the SAB that aeroallergen measurements would be in the domain of EPA's responsibilities (e.g., are aeroallergens considered air pollutants?), or whether they should be prioritized over ambient pollutants regulated by the Clean Air Act. In addition, setting up an aeroallergen monitoring network in more populated urban areas (in contrast to CASTNet, which samples more rural, less populated regions) may be a more valuable starting point for understanding how these measurements may aid the public. In general, any future aeroallergen measurements should also target areas with populations of people of color and those communities disproportionately affected by climate change (Stevenson et al., 2007; Wegienka et al., 2013; Lo et al., 2019). The SAB does not recommend one aeroallergen method over another at this time (Levitin et al., 2023).

Lastly, the SAB suggests that CASTNet sites with stable infrastructure could be available for other organizations to pilot aeroallergen monitoring programs. These synergies would likely be more useful at a subset of CASTNet locations with unique biota or nearby populations. The SAB may want to re-establish the monitoring and methods sub-committee that had been used in the past to evaluate new and existing air quality monitoring methods. The SAB could use this committee to advise on questions, such as this one before it considers implementing aeroallergen monitoring. In addition, there are other emerging questions regarding monitoring, such as those called for in proposed greenhouse gas regulations for the oil and gas industry. The reestablishment of this committee would be timely as more non-reference method sensors and instruments are deployed and as multiple needs continue to be present to advise the Administrator on monitoring technology, methods, data interpretation, and emerging stakeholder-initiated monitoring presented for action by the Agency, regulated communities, and industry.

2.4.2. Black carbon in precipitation

Black carbon is an important compound in the atmosphere because of the role it plays in air quality and its contribution to climate change, both through its radiative effects and deposition on snow and ice (Bond et al., 2013; Lee et al., 2013). There are not many continuous measurements of black carbon concentrations or deposition across the US but such measurements are needed to better understand the impact of wildfires on air quality and snow/ice albedo and melt (Bond et al., 2013; Lee et al., 2013; Kaspari et al., 2015). Data are also needed downwind of metropolitan areas to assess the fate and transport of combustion from diesel and urban sources and downwind of rural areas with domestic wood burning (Ahmed et al., 2014). Establishing black carbon measurements in precipitation at some CASTNet sites (especially remote snow-covered areas) could be a starting point for addressing these afore mentioned needs.

Nevertheless, the SAB does not consider this type of measurement a top priority for CASTNet. While understanding the black carbon wet depositional sink is key to understanding the black carbon budget and its changes over time, these measurements are of less value unless combined with ambient black carbon air concentration measurements, which are not part of the CASTNet measurement suite. Hence, the black carbon in precipitation data alone would be of limited value and as such would be a draw on CASTNet resources rather than a value add to the current suite of measurements.

The SAB also considers this type of measurement more of an active research topic (Sricharoenvech et al., 2022; Li et al., 2017) than ready-for-deployment. The SAB suggests that a pilot study at three selected CASTNet sites (Joshua Tree, Yellowstone, and Great Smoky Mountains national parks) could be considered. These sites are part of the ASCENT network (https://ascent.research.gatech.edu), which not only provides ambient real-time black carbon measurements but also several other aerosol measurements with which to contextualize BC data. Such a pilot study could characterize the key uncertainties around the black carbon budget and inform the design of a future network capability. Data from this pilot study could also inform the modeling of black carbon wet deposition on surface snow and ice cover, which is in line with the EPA strategic plan (i.e., the emphasis on reducing black carbon emissions that impact the Arctic). The SAB also recommends that NADP should be consulted, given that they are already measuring wet deposition of black carbon at several sites.

2.4.3. Continuous $PM_{2.5}$ concentration measurements

$PM_{2.5}$ is a serious human health risk and continuous measurements are needed to better understand the temporal dynamics of exposure. While SLAMS measures $PM_{2.5}$, CASTNet is unique in measuring some of the primary constituents of $PM_{2.5}$. Adding $PM_{2.5}$ to CASTNet sites would create a more robust multi-pollutant monitoring network for health and climate assessments. Together with some of the inorganic $PM_{2.5}$ constituents already directly measured, direct $PM_{2.5}$ concentration measurements would place constraints on non-measured aerosol components (e.g., organic carbon), as well as individual components' fractional contribution to $PM_{2.5}$. The SAB nonetheless cautions that this is not necessarily straightforward, given the difference in frequency of filter pack measurements, and the lack of size selectivity of the filter pack measurements. Nonetheless, the SAB thinks that researchers and stakeholders could use the $PM_{2.5}$ data meaningfully together with the inorganic constituent data to better understand changes in air quality with changing climate and precursor emissions, as the relative and absolute contribution of various species to PM2.5 is expected to change. Adding $PM_{2.5}$ to CASTNet should also be given consideration in light of: 1) the increasing contribution of wildfires to $PM_{2.5}$ in remote and rural regions, and 2) an expected future lowering of NAAQS levels for $PM_{2.5}$. $PM_{2.5}$ measurements would also support validation of satellite products of $PM_{2.5}$ and have value as a tracer for fire influence on other CASTNet measurements.

A range of different $PM_{2.5}$ monitors are available ranging from low-cost sensors to regulatory grade instruments. The SAB suggests that CASTNet consider addition of low-cost sensors at all network sites with the addition of regulatory-grade measurements at selected sites. For the latter, consideration should be given to sites that are above or near the NAAQS and that lack nearby State, Local and Tribal (SLT) monitors, are frequently impacted by smoke, for which models show a large uncertainty, and/or where a large organic aerosol fraction is likely prevalent and thus currently unconstrained. CASTNet should consult with EPA staff leading an effort to deploy low-cost sensors across the US.

2.4.4. Enhanced wildfire tracers (e.g., levoglucosan)

Wildfire smoke is of growing interest from a regulatory and monitoring perspective due to its impacts on human health and ecosystems. Adding fire tracer measurements to CASTNet may help reduce uncertainty in our understanding of air quality changes during wildfire events and assist in the interpretation of CASTNet measurements. A tracer such as levoglucosan would be a good indicator for residential wood burning, which is prevalent in many rural communities and can be hard to detect from satellites.

Fire tracers, however, have their limitations. While they provide indication on whether there may have been smoke impact on near-surface air sampled by the CASTNet monitors, relating the tracer measurements to impacts on ozone, NOx, and particulate matter in a meaningful (e.g., quantitative) way is complex (Jaffe and Widger, 2012; Jaffe et al., 2020). For example, tracers like levoglucosan are short-lived and cannot reflect the full extent of plume transport (Bhattarai et al., 2018; Li et al., 2021). Acetonitrile could also be used as a fire tracer but may also have atmospheric degradation and is emitted from sources other than wildfires. Consideration of fire tracer measurements warrants a discussion of the most appropriate tracers.

Overall, the SAB does not see that fire tracer measurements would add sufficient additional information over current available information such as available from satellite data or other smoke products. However, the addition of continuous $PM_{2.5}$ measurements could provide indicators of fire influences and be used as an indicator of when to sample filter packs for levoglucosan, acetonitrile, or potassium, which could assist State, Local and Tribal agencies with exceptional event demonstrations.

The SAB does however suggest that CASTNet include a flag in their data for possible or likely fire influences based on existing information. Information on smoke might also be available from IMPROVE filters with potassium and OC/BC components, and CASTNet should consider this information in designing any fire tracer or indicator data.

2.4.5. Replacement of or expansion of continuous ozone monitors

CASTNet is the only network in the US that provides consistent, high-quality, and long-term surface ozone concentration data at rural and remote sites and has been doing so for decades. The ability to understand if attaining the ozone NAAQS in any given area is achievable, how ozone levels have changed over time, and how ozone responds to changes in emissions and climate relies on consistent, high-quality, and long-term measurements of ozone at upwind rural and remote sites that are not strongly impacted by local sources. The extremely high value of the CASTNet ozone record has been clearly demonstrated by the large number of assessments and publications and heavy use by air quality managers and researchers (Cooper et al., 2012; Travis et al., 2017; Lin et al., 2017; Schultz et al., 2017; Fiore et al., 2015).

There are strong links between surface ozone and climate change (e.g., Jacob and Winner, 2009, Fiore et al., 2015, Fu and Tian, 2019). Precursor emissions and climate impacts on surface ozone concentrations differ across existing CASTNet sites, which is why retaining all, or at the least, the vast majority of current sites is fundamental to our ability to address scientific and policy questions surrounding air quality. As current CASTNet ozone instruments are aging, it is desirable to update the instrumentation to maintain capability. The SAB strongly recommends that continuation of the long-term high-quality ozone record should be a top priority.

If EPA implements additional secondary ozone NAAQS, the number and locations where regulatory ozone monitors will be needed will change significantly. Because most State, Local and Tribal ozone monitors represent populated areas and not areas associated with ecosystem impacts, CASTNet sites will be relied upon to inform where additional regulatory monitors would need to be added.

To save costs, EPA could consider transferring part of the network to lower-cost (and thus likely lower-quality) sensors. In this case, successful co-located measurements of old/new instruments for at least one year, and preferably longer, will need to be conducted to ensure consistency within acceptable bounds. The placement of regulatory grade sensors should be prioritized at sites with poor model performance, where there is a lack of nearby State, Local and Tribal monitors, to help define a non-attainment area, sites that represent true "background", and those that are needed to retain current limited capability in Western US.

The expansion of continuous ozone monitors to new sites in tribal regions (see Charge Question 5) would strengthen CASTNet and enhance the ability of CASTNet data to address new scientific and policy-relevant questions. Note that this should be done after, or concurrent with the replacement of the current generation of ozone monitors.

2.4.6. Expansion of passive ammonia concentration measurements

Ammonia is gaining in importance as an air pollutant as emission regimes and climate are changing. Ammonia emissions from fertilizer are strongly temperature dependent, and important sinks of ammonia include dry and wet deposition (Walker and Beachley, 2019 and references therein). Reliable, consistent long-term ammonia measurements are critical for informing current and future air quality modeling and management (Battye et al., 2019; Li et al., 2016). They are also necessary to validate new satellite retrievals of ammonia (Van Damme et al., 2014; Guo et al., 2021). The SAB recommends the addition of passive ammonia measurement within the context of this "Additional Measurements" section, given the important role of ammonia emissions in contributing to the atmospheric chemistry related to fine particulate matter.

Increased concentrations of ammonia and ammonium have been observed in some regions of the US (upper Midwest and near-coastal areas in the Mid-Atlantic) (Butler et al., 2016; Warner et al., 2017). New sources of ammonia are expected in the future (e.g., ammonia has been put forth as potential non-carbon-based fuel for the transportation sector; mostly for large engines like marine vessels (Tornatore et al., 2022)). Also, increased deployment of post-combustion carbon capture at fossil fuel power plants has the potential to result in increased ammonia or other nitrogen emissions (Spietz et al., 2017). With the short lifetime of ammonia in the atmosphere, a network of ammonia monitors is key to capturing unexpected and diverse sources.

With the decrease of emissions of SO_2 and NOx over recent years, ammonium is increasingly becoming an increasingly important fraction of PM2.5 over many regions in the US. Reduced nitrogen species are also becoming the dominant form of nitrogen in the atmosphere. Controls on ammonia emissions could be the next target for effectively reducing particulate pollution and reactive nitrogen.

Variability in ambient concentrations of ammonia and ammonium is still not well understood and there is a clear need for measurements that improve our understanding of current levels and our ability to model its behavior and spatiotemporal variations. Therefore, the SAB recommends that continuation of the current coverage and expansion should be a high priority.

Widespread measurements of ammonia were not readily available until the NADP implemented the AMoN network. CASTNet is a major supporter of AMoN sites. Wet and dry ammonium is measured at all sites where CASTNet is also measuring; important to characterize the budget and impacts of ammonia. With the short ammonia lifetime and its heterogeneous emissions, it is important to have a strategy in deciding where measurements are needed most to improve the geographic characterization of atmospheric ammonia concentrations across the US. In deciding on site locations both agricultural as well as non-agricultural areas need to be covered and future trajectories of energy and land use need to be considered.

Consideration should also be given to reviewing the current quality and value of the bi-weekly passive sampling. Higher time resolution would be beneficial for estimates of dry deposition and an automated ammonia instrument might be preferable over passive samplers, which are affected by interferences.

The following general recommendations on methods and approaches are noted:

Tier 1

- Long-term operation and consistency should be emphasized in replacing or adding any new instrumentation or capabilities to the network.
- Highest priority should be put on the replacement or expansion of ozone monitors given that current monitors are aging and there are already gaps in spatial coverage.
- Expansion of continuous ozone monitors to new sites that address existing gaps in spatial coverage (e.g., the central US in particular the region spanning North Dakota to Texas) and new sites on tribal regions, which would strengthen the CASTNet network and its ability to address new scientific and policy-relevant questions. Note that this should be done after, or concurrent with the replacement of the current generation of ozone monitors.

Tier 2

- Add passive ammonia measurements.
- Adding continuous PM2.5 to CASTNet sites would create a more robust multi-pollutant monitoring network for health and climate assessments, prioritizing areas downwind of, and impacted by, wildfire.
- Inclusion of a flag for possible or likely fire influences in the CASTNet data set based on existing information.

Tier 3

The SAB suggests that CASTNet consider a pilot study on measurements of black carbon in precipitation at three selected sites (Joshua Tree, Yellowstone, Great Smoky Mountains national parks). These sites are collocated with the ASCENT network which has real-time measurements of aerosol composition, including black carbon.

2.5. Charge Question 5.: Other Measurement Ideas.

Charge Question 5. Please advise on other pollutants or complementary measurements or instruments that could be considered to increase the value of the program (e.g., enhance Tribal and rural monitoring capacity, support NAAQS monitoring to empower communities).

The infrastructure in place across the CASTNet network provides a robust platform to implement additional temporary or permanent measurements which can provide critical chemical and physical measurement data to address the needs of climate change adaptation, environmental justice, and other goals as stated in EPA's FY22-26 strategic plan. These new or expanded measurement suites need to be evaluated for inclusion based on their scientific usefulness as well as the required resources needed for implementation of measurements and associated quality control and data analysis. The criteria for such an evaluation would need to be developed, based on the scientific consensus formed from the literature as well as new research if resources permitted. The response to Charge Question 4 describes priorities for measurements that most complement CASTNet's current capabilities, with an emphasis on promoting the network's continued operations. While the SAB determined that was a higher priority over adding new measurements that would take CASTNet in a new direction, that determination may change in the future. Along with provision of the table of potential network metrics and characteristics (see Appendix A) that can be used to assess the value of new or expanded measurement suites, the response to Charge Question 5 includes discussion on a variety of suggested measurement ideas that would serve to improve CASTNet if the resources are available.

The SAB notes the following additional pollutants and complementary measurements or instruments that can increase the value of the program.

- Modernizing CASTNet is imperative. Online instruments and newer techniques should be deployed to provide high quality, high temporal resolution, continuous measurement data of critical parameters, which will improve the efficiency of CASTNet, improve the quality of measurement data, and capture large spatiotemporal variabilities in the air quality impact of extreme and exceptional events (e.g., wildfires).

Extreme or exceptional events most often occur abruptly and can last for varying time periods and levels of intensity. To capture such large variability, the temporal resolution of sampling needs to be at least hourly for critical parameters. NOx, VOC, and meteorological measurements are fundamental for understanding the drivers of ozone exceedances, deposition, and transport, and long-term meteorological data are essential for quantifying climate change and its impacts on air quality. CASTNet's ozone, NO, and NOy measurements are hourly, but its PM measurement data are weekly, which conceivably flattens those event-induced spikes on smaller time scales, and thus logically the impacts of exceptional or extreme events on air quality and deposition fluxes were probably biased low when estimated using those filter pack data. As extreme weather events such as heatwaves, severe rainfalls and drought occur more frequently driven by climate change (BAMS Reports, 2011-2020, https://www.ametsoc.org/index.cfm/ams/publications/bulletin-of-the-american-meteorological-society-bams/explaining-extreme-events-from-a-climate-perspective), finer temporal measurements are needed for locations that are identified to be most impacted. In addition, it is important to ascertain what is truly measured in filter packs and whether the current filter pack approach is fit for studying extreme or exceptional events. For example, NH_3 measurements using filter packs may have confounding issues such as interference with p-NH_4 and evaporation and fast chemical transformation (Andersen and Hovmand, 1994). Recent research findings showed that during a wildfire event, a large fraction of NH_3 was transformed to NH_4^+ two hours after emissions in fire plumes hampering capturing the real influence of fires using filters (Tomsche et al., 2023). Sickles and Shadwick (2008) showed median biases of 35% - -25%, reaching 44% in the summer, in NO_3^- concentrations measured from CASTNet's weekly samples compared with IMPROVE's 24h samples. The large summertime median bias was consistent with volatilization losses of particulate NO_3^- in the CASTNet sampler at high temperatures and low ambient concentrations of NO_3^- that were often observed in summer. Modern instruments that are capable of long term, real-time measurements of speciated PM2.5 components are now available. For instance, the Aerosol Chemical Speciation Monitor (ACSM, Ng et al., 2011) is designed for standalone, long-term, routine measurements of nitrate, ammonium, sulfate, chloride, and organics, which also captures signatures of wildfire smoke (e.g., levoglucosan) at the same time. The ASCENT network is a new, high-time-resolution (mins), advanced aerosol measurement network in the US, each site has four real-time instruments: ACSM (organics, inorganics), Xact (metals), aethalometer (black carbon, brown carbon), and Scanning Mobility Particle Sizer (SMPS; particle size distribution, number concentration). Three ASCENT sites (Joshua Tree, Yellowstone, and Great Smoky Mountains national parks) are co-located with CASTNET sites, providing an opportunity for CASTNET to gain exposure to these newer instrumentations. At the same time, the complementary aerosol and gas measurements from the two networks provide the essential data for understanding pollutant sources, evolutions, and properties in a changing climate.

It is time to consider using modern, online approaches. Despite significant initial expenses deploying modern, online instruments and new techniques will save effort and resources in the long run and provide continuous, real-time data (Bressi et al., 2021). Such datasets will be critical to evaluating impacts of climate change, extreme and exceptional events, and the changing emission profiles driving observed atmospheric air pollution chemistry as well as performing assessments of health impacts on disadvantaged communities and ecosystems.

Low-cost sensor deployment is needed. Low-cost sensors can provide real-time data near residences in non-compliance and in rural and Tribal communities. These sensors can also address the spatial coverage issues mentioned earlier. Visualization of sensor hourly real-time data together with filter pack data should be made accessible to rural and Tribal communities near CASTNet sites. However, there is generally a continued need to understand and improve the performance of low-cost sensors in different environments, which is beyond this SAB's purview.

Communities are most concerned with the air they breathe. Therefore, providing real-time measurement data of ambient concentrations of criteria pollutants where residences are most directly meets community-level needs. The current state-of-the-science of low-cost sensors is still in question (Kang Et al., 2022). It remains a general research topic to evaluate and improve the performance of low-cost sensors, and currently the EPA does not approve or implement sensors. With community consensus on their performance becoming available and EPA's approval, lower-cost sensors can be used to increase the spatial coverage of $PM_{2.5}$ and gaseous pollutant measurements (e.g., ozone, NO_2). If the performance quality of lower-cost sensors is appropriate and EPA approves their implementation in the network, co-location with the instrument to be replaced for at least one full annual cycle and perhaps longer is recommended to capture how meteorological and biological variations by season (e.g., presence of confounding chemicals, effects of temperature, relative humidity, and solar radiation) or irregular or extreme weather events may affect instrument performance. If the design value for one of the pollutants exceeds a certain threshold percentage value of a NAAQS, and subsequently the data are needed to define a nonattainment area, the EPA should consider replacing the sensor with a regulatory monitor. The hourly data from evaluated and calibrated low-cost sensors should be visualized on a live CASTNet website, alongside interpretive information providing descriptions of the data and relevant thresholds, ideally in a multi-lingual format, so that the communities have access to real-time air quality observations. The SAB suggests that the real-time data be interpreted by a science communicator familiar with the communities served by the monitors, addressing a part of the goal related to EJ. This provides the communities with timely information and assurances, especially when there is an air quality event. The filter pack data should also be presented on the same live website as longer-term averages in convenient units (ppb and $\mu g/m^3$) with relevant trends, which can provide the communities with long-term perspectives for the present air quality.

The SAB also suggests:

- Upgrades with enhanced measurement payloads at the sites that are identified as the most vulnerable to extreme or exceptional events and climate change. Expand Tribal sites. This directly meets the needs of Environmental Justice, one core issue in EPA's FY22-26 strategic plan, by addressing Objectives 2, 4, 6, 7, and 8 as shown in Appendix A. The most recent new Tribal sites, located over the Great Plains where a monitoring gap exists, are funded through a cost-sharing arrangement that has allowed CASTNet to expand Tribal monitoring capacity. That is an effective funding mechanism and could be prioritized to continue expanding Tribal sites.

- Support MDN's deployment of Hg passive samplers, in particular at Tribal sites and others that rely on fishing. Mercury is a constituent of heightened concern in Tribal communities and should be considered for prioritization. Information of greatest value to tribes includes monitoring of fish mercury as well as concentrations in atmospheric deposition; similarly, proposed effectiveness evaluation indicators for the Minamata Convention would take a multi-media approach with abiotic and biotic measurements. Hence, appropriate mercury monitoring requires efforts across a broad array of programs to be most informative.

- Use stable isotope techniques to analyze archived samples for source attribution studies. Isotope techniques can be a powerful tool to identify specific emission sources for pollutants arising from many different processes due to unique isotopic signatures by source types (e.g., biogenic vs. combustion) and isotopic fractionation (i.e., changes) occurring during physical and chemical transformations in the atmosphere. This information may inform understanding of contributing factors to NAAQS nonattainment and identification and quantification of extreme/exceptional event impacts on US baseline air quality. For example, stable isotopic composition of the organic fraction of nitrogen in aerosols is far from certain, while that of inorganic nitrogen in gases and aerosols has been successfully used for source attribution in numerous studies. It will be a big step forward if isotopic composition of organic nitrogen in aerosols can be determined.

- Measurements of formaldehyde. Formaldehyde is a toxic gas with serious health impacts, which was identified as a national cancer driver by the 2019 AirToxScreen. It is a key reactive gas in atmospheric chemistry and is relevant for ozone production. Formaldehyde measurements can help evaluate ozone and particle model simulations and validate satellite retrievals (Wang et al., 2022; Cazorla et al., 2015) and commercial instruments are available for routine, long-term measurements of formaldehyde (Mouat et al., 2023). Assessments of how PAMS and other field studies have benefited from measurements of aldehydes may provide insight to whether such an addition could be valuable to CASTNet. Assuming the measurements have proven useful there, a pilot would be conducted at a select set of CASTNet locations based on the criteria as shown in the Appendix, where contrasting ozone model performances have been shown, downwind of wildfire regions, and/or collocated with a full suite of measurements of other trace gases and the physical and chemical properties of particulate matter.

- Dry deposition of reactive gases and aerosols. There is renewed interest in the role of dry deposition in ambient pollutant concentrations, yet we have poor understanding and predictive ability of dry deposition variability in space and time. Currently dry deposition fluxes of pollutants are estimated using modeling tools with large uncertainties (Clifton et al., 2020, 2023; Schwede et al., 2011; Wu et al., 2016). It is important to advance the models using observations of dry deposition. We need eddy covariance fluxes for the best observational constraints on dry deposition (Guenther et al., 2011; Farmer et al., 2021; Clifton et al., 2020; He et al., 2020). However, current CASTNet sites are not ideal for eddy covariance fluxes because they are often in clearings.

The following recommendations are noted:

Tier 1

- Highest priority should be put on modernizing CASTNet, as online gas-phase (NH3, VOC) and particle instruments (PM2.5, aerosol composition) and state-of-the-science technologies can provide high-time resolution data that are essential for understanding the climate and health impacts of sources with high temporal variability (e.g., wildfires), as well as for sound assessment studies and timely communication to the public and stakeholders. Measurements of NOx and meteorological variables concurrent with those of O_3 should be deployed at all sites due to their fundamental roles in determining ozone exceedances, emissions, deposition, and transport.
- Deployment of low-cost sensors accompanied by visualization and interpretation of the resultant data can help address the spatial coverage issue and to better serve with real-time data the residents in the disadvantaged communities and Tribal land surrounding the CASTNet sites, contingent upon proved performance of low-cost sensors and EPA’s approval for implementation.

Tier 2

- Expansion of Tribal sites should be prioritized as Environmental Justice is one major component of EPA’s FY22-26 strategic plan.

- Support for MDN's deployment of Hg passive samplers, in particular at Tribal sites and others that rely on fishing, should be prioritized, because mercury is one heightened concern in Tribal communities.
- Employment of stable isotope techniques should be prioritized for analysis of archived samples for source attribution studies.
- Measurements of formaldehyde should be considered for its health impacts as well as its important role in ozone photochemistry and its source origins from wildfires and anthropogenic activities.

Tier 3

- For a site with deployment of low-cost sensors, EPA should consider replacing a low-cost sensor with a regulatory monitor if the design value approaches a NAAQS level contingent upon proved performance of low-cost sensors.
- Dry deposition of reactive gases and aerosols should be considered for long-term enhancement of CASTNet's capabilities due to its critical roles in determining budgets of trace gases and aerosols as well as their health impacts on human and ecosystems.

2.6. Charge Question 6.: Additional Analyses.

Charge Question 6 Please advise on new data analyses that CASTNet could undertake to improve EPA's ability to characterize air quality and atmospheric deposition impacts to rural and disadvantaged communities using existing data and resources.

The Clean Air Status and Trends Network (CASTNet) is a national long-term monitoring network that provides data to characterize ambient air pollutant concentrations in disadvantaged, rural communities, estimate air pollutant deposition and quantify its ecological effects, and assess the efficacy of Agency air pollution control programs.

Evidence emerging from wildfire smoke suggests that CASTNet can improve EPA's ability to characterize $PM_{2.5}$ data from wildfires that impact rural and disadvantaged communities. According to studies by Tessum et.al, 2021, Black Indigenous and People of Color (BIPOC) are frequently, disproportionately exposed to air pollutants especially fine particulate matter ($PM_{2.5}$) and the resulting adverse health effects which includes lung and heart diseases, particularly those with underlying health conditions, the young and elderly, and other vulnerable populations. The racial and ethnic disparities in air pollution exposure levels were observed across all states in the United States and in urban and rural areas. This study (Tessum et.al, 2021) used EPA data contained in the National Emissions Inventory with over 5000 emission sources for ($PM_{2.5}$) including industrial, agricultural, light, and heavy-duty vehicles, construction, and residential sources.

EPA's goal "to provide an environment where all people enjoy the same degree of protection from environmental and health hazards and equal access to the decision-making process to maintain a healthy environment in which to live, learn, and work". CASTNet's mission is to provide data to characterize ambient air pollutant concentrations in disadvantaged, rural communities, estimate air pollutant deposition and quantify its ecological effects, and assess the efficacy of Agency air pollution control programs. Therefore, it is imperative that the current monitoring and data collection tools for characterization of air quality and atmospheric deposition be revamped and enhanced for local community access and interpretation (Tier 1), to address air quality concerns and health impacts in overburdened communities. It is recommended that EPA prioritize the provision of scientific expertise and tools to assist tribes, and other overburdened communities to address environmental justice and equity issues.

Tribes have historically played an important role in investigating environmental issues including air quality and climate change. Tribes bring unique perspective and direct action resulting in pollution reduction and documentation of air pollution's negative health impacts. Establishment of community-based air monitoring programs with portable monitoring and measurement equipment that provide real-time data and, easily interpretable data analysis, are critical for these communities. The opportunity of using CASTNet site data for quality control and evaluation, will be very valuable for air quality characterization and management in disadvantaged communities. Successful Tribal air quality monitoring programs such as the one implemented by the National Tribal Air Association which provides annual Status of Tribal Air Report (STAR) to Tribal Nations, EPA, other federal agencies and interested parties, and offers an overview of Tribal Air Quality Programs for current administration is an excellent example.

Robust education for citizen scientists and the general public on the use of the EPA Air Sensor Toolkit that allows utilization of air sensor monitors that are inexpensive, portable, and generally easier to operate than regulatory-grade monitors would be valuable in monitoring and understanding air quality conditions in the overburdened community. It is critical that the Tribal air monitoring programs and other community-based organizations work in tandem with the State or Local Air Monitoring Stations (SLAMS) Network, as well as other ambient air related networks such as IMPROVE, CASTNet, NADP, for comparison, evaluation, and quality control with National Ambient Air Quality Standards (NAAQS). Use of monitoring technologies that automatically measures and records airborne particulate concentration levels of (PM_{10}) and ($PM_{2.5}$) will dramatically increase the air quality monitoring in Tribal nations and other overburdened communities. Additionally, it is recommended that a comprehensive education and outreach initiative be implemented to enable the Tribal and overburdened communities to better understand the relevance of the air quality and atmospheric deposition data impacts on their health and daily activities, and to make informed decisions.

Providing training and technical assistance on the use and interpretation of AirNow will allow the Tribal nations and overburdened communities to monitor and interpret air quality standards in real time within their communities and make informed decisions to reduce/prevent exposure to air pollutants including PM_{10}, $PM_{2.5}$, and ozone, and associated hazards especially for vulnerable groups of people.

It is recommended for education and outreach initiatives to incorporate the following for a meaningful collaborative community engagement:

- Incorporation of linguistic and cultural competence in engagement efforts (Tier 1). When working with tribes and tribal communities, and other overburdened groups it's important that

EPA staff and other stakeholders are aware of and respectful toward the diverse cultures, languages, histories, and contemporary issues facing Native American tribes. Therefore, SAB suggests that the agency collaborates with tribal leaders and indigenous experts to develop linguistic and culturally appropriate educational materials, fact sheets, and data dashboards. This collaboration would ensure that information is not only technically accessible but also respects and reflects the cultural contexts of the tribes. For example, traditional ecological knowledge (TEK) could be integrated into air quality monitoring and assessments.

- Perfluoroalkyl substances (PFAS) and Perfluorooctanoic acid (PFOA) are used in many commercial applications, persistent in the environment, have long residence time in the environment, do not easily undergo chemical biodegradation or biotransformation, and bioaccumulates in both blood serum of those exposed in their workplace blood and tissues of the general population (Kudo and Kawashima 2003 ; Sanchez Garcia et al., 2018) including children and adolescents (Duffek et al., 2020 and Li et al., 2021). Worley, Moore, and Tierney et al., (2017) reported that the biological half-life of PFOA and PFAS in humans is approximately 2 to 4 years. Studies by Bartell and Vieira (2021) indicated a link between exposure to PFOA and PFAS to kidney and testicular cancers. Black and Hispanic/Latino communities are disproportionately exposed to harmful levels of PFAS in their water according to studies by researchers from Harvard T.H. Chan School of Public Health (Jahred et. al., 2023). Therefore, EPA should consider monitoring and measurement of PFAS in atmospheric deposition (Tier 3), as well as in bodies of water and soil in disadvantaged communities, where exposure is likely to be disproportionately higher due to proximity to pollution sources and have adverse health impacts.

- Lastly, adoption and incorporation of the Climate and Economic Justice Screening Tool (CEJST) to considerations for network evolution, as illustrated in Appendix A are suggested. Using datasets that are indicators of burdens in eight categories: climate change, energy, health, housing, legacy pollution, transportation, water and wastewater, and workforce development will be relevant in addressing the monitoring and data collection gaps in these disadvantaged communities. EPA is focusing attention to environmental justice issues in all matters related to air quality monitoring, evaluation, and management so following through with these recommendations would seem to be a high priority for the Agency.

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APPENDIX A: Scoring CASTNet Objectives

This appendix offers an approach to articulate and prioritize the scientific and policy objectives for the network and identify which locations or combinations thereof best meet the overall needs of the agency. The elements of these tables can identify the extent to which modifications to the network would improve, optimize or retain the net utility of CASTNet, while retaining long-term viability. Decisions could include expanding or contracting the number of stations, sampled species or time resolution.

The scientific and policy objectives in the Tables 1 and 2 are ordered and numbered from left to right based on the SAB's sense of their relative importance to facilitate cross referencing. As per the SAB's response to the charge questions, long-term trends assessment and coverage of important but under-sampled regions (e.g., rural) are the two most important objectives of CASTNet; it has successfully operated and met those objectives for decades.

An expansion of spatial, temporal and/or compositional capability of the network could further optimize CASTNet's ability to meet its objectives. Use of Tables 1 and 2 can assist with the prioritization of which sites or capabilities to add. The Tables can also be used for individual site assessment to identify locations that might be duplicative, locations which may only support 1 or 2 objectives, or locations that support lower-priority objectives. Most sites will likely support multiple objectives. However, the value obtained from an individual site is not necessarily correlated with the number of objectives it meets (e.g., it could be in a critical location or have a critical capability).

Table 1 (Qualitative Objectives and Metrics for CASTNet Evaluation) presented is the initial thoughts compiled by the CASTNet Review Panel at the May meeting. It is considered insightful and valuable, in and of itself, and is offered in this Appendix to add to the record.

- To use Table 1 effectively, for each site, it is suggested to evaluate the extent to which it meets the prioritized objectives on a scale of 1 to 5, with one being 'does not meet', and 5 being 'meets completely'. For one suggested ranking scenario one might give a weighting to the various objectives, and that becomes a multiplier to the 1-5 scale assignments by cell. In this approach each site would have an equation such that one could sum (over all objectives) and weight the score by multiplying the objective weighting factor to develop a sense of the relative ability to meet network objectives via the scale value calculated. Then one could order all the locations from high to low as a first step to decide which locations serve more outcomes tied to key objectives. One could then go down the list and assess the overall extent that each objective can still be met, and also bring in resources to see how far down the list the resources may last or justification for additional resources could be developed. This step could include an assessment of potential new monitoring locations to identify gaps in the existing network composition.

Table 2 (Example Specific Metrics for CASTNet Evaluation) is subsequently derived from further work of the SAB CASTNet Review Panel to address the multiple issues raised across the charge to the SAB to provide insight, guidance, and some sense of prioritization to inform the evolution of the CASTNet monitoring network. The guidance offered here is not prescriptive, but illustrative and should be used as a guide for the difficult choices facing the network managers into the future.

- The evaluation system described in Table 2 is a way to help assess the extent to which a location meets each objective, as well as weigh the relative benefits of scenarios addressing different priorities. In addition to evaluating each objective for each site, the system can be used to highlight specific benefits for any particular location. Some locations may be more expensive to operate, but they may also be superior sites, achieving more objectives (and therefore worth the added expense). For example, the long-term sample availability at several sites, collocated with the latest new and emerging instrumentation, would rank with a high score for detecting long term trends and serving as a measurement platform and for high quality measurements. This might suggest that preserving some sites for this purpose, at least for a time to establish equivalency between methods, would score high and be a contender for ongoing resources and investment.

Table 1: Qualitative Objectives and Metrics for CASTNet Evaluation

CASTNET Objective	1. Detect and Quantify Long-Term Trends	2. Geographic Patterns (Concentration, fate transport)	3. Evaluate and Improve Models & Data Products	4. Characterize Atmospheric Background Air Quality	5. Detect and Quantify Climate-Air Quality	6. Serve as Measurement Platform for Air & Ecology Metrics	7. Improve Sampling Quality / Freq. in DACs & Tribal Lands
EPA Strategic Goal Supported	Tackle Climate; Enforce Law; Ensure Clean Air	Tackle Climate; Enforce Law; Ensure Clean Air	Tackle Climate; Advance EJ; Enforce Law; Ensure Clean Air	Tackle Climate; Advance EJ; Enforce Law; Ensure Clean Air	Tackle Climate, Advance EJ; Ensure Clean Air	Tackle Climate; Enforce Laws; Ensure Clean Air	Tackle Climate; Advance EJ; Ensure Clean Air
Key Parameters	Ozone, PM2.5	Ozone	Ozone	Ozone	Meteorology, O3, NOx, PM, and BC		Ozone, PM2.5
Frequency	Sampling frequency reduced	Sampling frequency reduced	Hourly	Hourly	Hourly		Hourly
Specific qualitative metrics to Evaluate relative to objective.	Current or expected statistically significant key parameter trends. Including sites with no current trends. Demonstrate need and efficacy of regulations targeting interstate pollutant transport.	Distributed across ecoregion and land use types Demonstrate need and efficacy of regulations targeting interstate pollutant transport.	Correlation analysis indicates significant differences with nearby sites Geographic diversity	Range of sites is spatially distributed, dominantly rural, away from sources High elevation/ mountain sites incl. Proximity to national and/or state borders (e.g., "good neighbor" and transboundary)	Range of sites is spatially distributed High elevation/ mountain sites incl. Long term trend site. Commitment to >decade of network support	History of visiting researchers or field campaign (e.g., ground or aircraft) coordination Ability to mitigate culturally significant resource damage (i.e. utility for secondary standard comparison) Potential to detect emerging contaminants of concern (health based)	Measures metrics of community concern (e.g., Hg) Reflects variety of DAC and Tribal demographics Population density for health metrics Underrepresented ecoregions on tribal lands

Table 2: Example Specific Metrics for CASTNet Evaluation

CASTNET Objective	1. Detect and Quantify Long-Term Trends	2. Geographic Patterns (Concentration , fate transport)	3. Evaluate and Improve Models & Data Products	4. Characterize Atmospheric Background Air Quality	5. Detect and Quantify Climate-Air Quality	6. Serve as Measurement Platform for Air & Ecology Metrics	7. Improve Sampling Quality / Freq. in DACs & Tribal Lands
EPA Strategic Goal Supported	Tackle Climate; Enforce Law; Ensure Clean Air	Tackle Climate; Enforce Law; Ensure Clean Air	Tackle Climate; Advance EJ; Enforce Law; Ensure Clean Air	Tackle Climate; Advance EJ; Enforce Law; Ensure Clean Air	Tackle Climate, Advance EJ; Ensure Clean Air	Tackle Climate; Enforce Laws; Ensure Clean Air	Tackle Climate; Advance EJ; Ensure Clean Air
Below are specific metrics that deem a CASTNET site as more valuable in meeting objectives, these consider cost effectiveness of the site							
Most recent design value meets the NAAQS Yes = 0 No = 1							
Site is new and > 500 Miles from another CASTNet site (6 levels out with existing sites metrics) Yes = 6							
Sites are spatially distributed with respect to other networks and CASTNET sites. Yes = 1							
Site has a propensity for propensity for extreme events (i.e. wildfires) Yes = 1							
Site is new and > 500 Miles from another CASTNet site Yes = 5							
co-location with other networks 1 point per "other network co-location"							
Number of key pollutants 1 point per pollutant including met							
Infrastructure condition Shelter < 15 years old = 1							

The following provides an example of how Tables 1 and 2 could be applied when considering re-evaluation of sites with specific goals (row 2) in mind. One could also prioritize sites using Tables 1 and 2 with specific CASTNet objectives in mine (row 10). In the example the goals of the re-evaluation are to advance Environmental Justice and provide improved spacial coverage nationally (as was suggested by the SAB) by weighing the value of existing sites vs. a new site.

Scenario: CASTNet is considering re-prioritization of sites to meet EPA Strategic Plan Priorities with a focus on advancing Environmental Justice and improving spatial distribution as was noted by the SAB in the Great Plains states.

- Chloe Lake Site - Ozone only, rurally located on the East Coast
- Party City USA Site - Ozone only, located near a mid sized urban center in Michigan
- Nebraska New Site - Ozone only, rural known transport region

CASTNET Objective	1. Detect and Quantify Long-Term Trends	2. Geographic Patterns (Concentration, fate transport)	3. Evaluate and Improve Models & Data Products	4. Characterize Atmospheric Background Air Quality	5. Detect and Quantify Climate-Air Quality	6. Serve as Measurement Platform for Air & Ecology Metrics	7. Improve Sampling Quality / Freq. in DACs & Tribal Lands
EPA Strategic Goal Supported	[illegible]	[illegible]	Tackle Climate; Advance EJ; Enforce Law; Ensure Clean Air	Tackle Climate; Advance EJ; Enforce Law; Ensure Clean Air	Tackle Climate, Advance EJ; Ensure Clean Air	Tackle Climate; Enforce Laws; Ensure Clean Air	Tackle Climate; Advance EJ; Ensure Clean Air
K[illegible]	Ozone, PM2.5	Ozone	Ozone	Ozone	Meteorology, O3, NOx, PM, and BC		Ozone, PM2.5
Fr[illegible]	Sampling frequency reduced	Sampling frequency reduced	Hourly	Hourly	Hourly		Hourly
Specific qualitative metrics to evaluate relative to objective.	Current or expected statistically significant key parameter trends. Including sites with no current trends. Demonstrate need and efficacy of regulations targeting interstate pollutant [illegible]	Distributed across ecoregion and land use types Demonstrate need and efficacy of regulations targeting interstate pollutant transport.	Correlation analysis indicates significant differences with nearby sites Geographic diversity	Range of sites is spatially distributed, dominantly rural, away from sources High elevation/ mountain sites incl. Proximity to national and/or state borders (e.g., "good neighbor" and transboundary)	Range of sites is spatially distributed High elevation/ mountain sites incl. Long term trend site. Commitment to >decade of network support	History of visiting researchers or field campaign (e.g., ground or aircraft) coordination Ability to mitigate culturally significant resource damage (i.e. utility for secondary standard comparison) Potential to detect emerging contaminants of concern (health based)	Measures metrics of community concern (e.g., Hg) Reflects variety of DAC and Tribal demographics Population density for health metrics Underrepresented ecoregions on tribal lands

Step 4: If needed, work each site through the matrix for the goals that are prioritized.

CASTNET Objective	1. Detect and	2. Geographic Patterns (Concentration, fate transport)	3. Evaluate and Improve Models & Data Products	4. Characterize Atmospheric Background Air Quality	5. Detect and Quantify Climate-Air Quality	6. Serve as Measurement Platform for Air & Ecology Metrics	7. Improve Sampling Quality / Freq. in DACs & Tribal Lands
EPA Strategic Goal Supported	Tackle Climate; Enforce Law; Ensure Clean Air	Tackle Climate; Enforce Law; Ensure Clean Air	Tackle Climate; Advance EJ; Enforce Law; Ensure Clean Air	Tackle Climate; Advance EJ; Enforce Law; Ensure Clean Air	Tackle Climate, Advance EJ; Ensure Clean Air	Tackle Climate; Enforce Laws; Ensure Clean Air	Tackle Climate; Advance EJ; Ensure Clean Air
Below are specific Metrics that deem all CASTNET sites more valuable in meeting all objectives, these consider cost effectiveness of the site							
Most recent design value meets the NAAQS Yes = 0 No = 1			Chloe Lake = 0 Party City = 1 Nebraska = 0				
Site is new and > 500 Miles from another CASTNet site (6 levels out with existing sites metrics) Yes = 6			Chloe Lake = 0 Party City = 0 Nebraska = 6				
Sites are spatially distributed with respect to other networks and CASTNET sites. Yes = 1			Chloe Lake = 0 Party City = 0 Nebraska = 1				
Site has a propensity for propensity for extreme events (i.e. wildfires) Yes = 1			Chloe Lake = 1 Party City = 0 Nebraska = 0				
co-location with other networks 1 point per "other network co-location"			Chloe Lake = 1 Party City = 1 Nebraska = 0				
Number of key pollutants 1 point per pollutant including met			Chloe Lake = 2 Party City = 2 Nebraska = 0				
Infrastructure condition Shelter < 15 years old = 1			Chloe Lake = 1 Party City = 0 Nebraska = 0				

Step 5: Consider the results
Chloe Lake = 5
Party City = 4
Nebraska = 7