Interactions of Air Pollutants, Ecosystems, Human Health, and Policy

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1) Description of discovery opportunity. Air pollution is the world's single largest environmental health problem, accounting for 7 million premature deaths annually (World Health Organization, 2014). Moreover, air pollution has negative effects on Earth's ecosystem, including impacts on biodiversity and crop yields (Organization for Economic Co-operation and Development, 2016). These concepts do not exist in isolation: pollutants can be chemically transformed in the atmosphere and react with other pollutants, allowing them to migrate between the air, water, and food, and, thereby, impact human health. Therefore, research is needed to understand how exposures to air pollution impacts both human and ecological health, and to support the development of policies and management strategies (and their implementation) to decrease human and ecological harm. ESF currently has broad faculty expertise in air pollution, but we are limited in our ability to conduct high-quality research due to limits on resources, opportunities for formal training for students, and community engagement. Thus, for this Challenge our overarching goals are threefold: ***(1) to advance understanding of the chemical properties of airborne contaminants that impact people and ecosystems, (2) to develop curricula at ESF to teach our students about the importance of air quality and community/ecosystem health,*** and ***(3) to develop better environmental policies through analysis, community engagement and school-based outreach.***

Our first major step towards accomplishing these goals is to set up two state-of-the-art atmospheric research stations with matching air quality instrumentation on the ESF campus (urban site) and at Huntington Wildlife Forest (HWF, remote site). Having two locations will allow us to study differences in air pollutants from varied sources, as well as allowing us to assess the transport of pollutants within New York State. These stations, as well as the pollutants we propose to measure, can be used for research projects spanning multiple disciplines simultaneously, increasing their utility to ESF. Specifically, we want to set-up simultaneous measuring stations at ESF and HWF for airborne particles with a diameter less than 2.5 μm ($PM_{2.5}$), black carbon (BC, a portion of $PM_{2.5}$), ozone (O_3), carbon monoxide (CO), and nitrogen oxides (NO_x). These pollutants are regulated by the US Environmental Protection Agency, which sets its standards based on protecting human health as well as ecosystems and the built environment.

Specific research issues include:

A) Black carbon (BC), which is tied closely to diesel exhaust and has been repeatedly shown to influence respiratory and cardiovascular health in humans. Together with measurements of metals using existing A&TS equipment, monitoring of BC and its composition will enable determination of emissions sources of $PM_{2.5}$. In combination with epidemiological and toxicological studies, this monitoring would help quantify the human health impacts of these key pollutants, particularly in the vulnerable populations of Central New York.

B) When combined with information from the HWF site and sites run by collaborators at the University of Albany, this instrumentation will enable us to determine how air pollutants travel across New York State.

C) Excess atmospheric nitrogen deposition can directly affect clean water, climate, food, recreational opportunities, and cultural and spiritual value. Nitrogen deposition is emerging for the next decade as a top priority of multiple agencies such as the EPA, National Atmospheric

Deposition Program, and National Park Service. Moreover, the chemistry and transport of gaseous pollutants is intertwined with that of PM, so that these pollutants need to be studied together (see Figure 1). As a consequence, one must study gas-phase pollutants, nitrogen cycling, and PM, *jointly,* to understand PM formation and the health effects of air pollution.

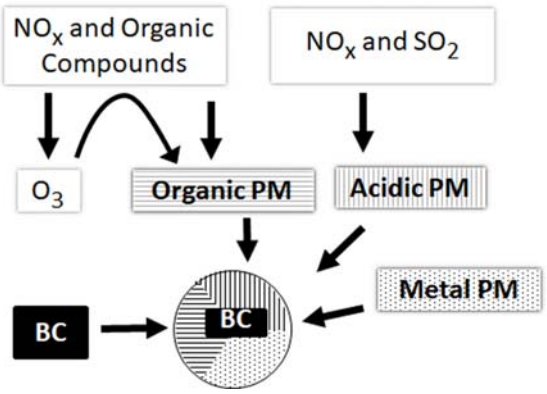

Figure 1: Interaction of gas-phase pollutants with each other and PM that influence the nature of PM.

D) Mercury (Hg) impacts neurological development in humans and wildlife. The atmosphere transports mercury globally, but regional and global models use unreliable and incomplete reaction mechanisms that yield unreliable spatial distributions for Hg deposition. Human health impacts mostly occur via fish consumption, so biological uptake of Hg in food webs represents a critical topic of study. Linking Hg deposition to Hg dynamics in fish and wildlife would represent a critical step towards advancing the goal of the Minamata Convention: to limit the human health impacts of Hg.

E) The interactions between gas-phase pollutants and among these pollutants and PM require policy analyses that encompasses the impacts and control of multiple pollutants. Because air pollution issues transcend national boundaries, we will study policy dynamics at the local, regional, and international levels.

2) Undergraduate and graduate programs that will be impacted. This initiative will help improve undergraduate programs in Chemistry, Environmental and Forest Biology, Environmental Health, and Environmental Science by making the resources from these stations available for class projects. For example, we have already identified two courses - Environmental Sampling Methods (EHS 360/560) and Methods of Environmental Chemical Analysis (FCH 515) - that want to use these resources to give students hands-on experience using the state-of-the art equipment and creating hypothesis-driven, research-based laboratory projects. In addition, these research projects and resources will draw in faculty and graduate students in ERE, FNRM, GPES, Env. Studies, PBE, FCH, and EFB, who already study these particular pollutants and/or the processes controlling their fate and transport. We would also introduce a new EHS course focusing on Air Pollution, Health, and Policy; this would complement ESF's existing air quality courses.

3) List of agencies for future funding. Lead investigators on this proposal have previous obtained funding from the Department of Energy, NYS Energy Research and Development Authority, Environmental Protection Agency, and the National Science Foundation. We would continue to seek out funding from these institutions for this project. We also have experience with submitting proposals to the National Institutes of Health, Health Effects Institute, National Institute of Standards and Technology, and the Food and Drug Administration, and we will continue to apply to these agencies to support the proposed work. The American Heart Association is a potential source of new funding, and the American Lung Association has just published its first RFP for policy-oriented studies. SUNY's Empire Innovations program is also a potential funder of many aspects of the proposed research.

4) Expanding and creating new partnerships. Members of this team have been very active in collaborating with partners at other local and regional organizations, including Brooks Gump (Public Health) and Charley Driscoll (Engineering) at SU, Guirong Wang (Surgery) and Chris Morley (Epidemiology) at Upstate, as well as Everette Joseph and Chris Thorncroft (Atmospheric Science) at the University of Albany. Other collaborations include Harvard, Environment Canada, and many universities in Asia and Europe. Funding of this proposal would broaden and strengthen these collaborations. We have also identified potential new partners who are interested in working with us, including Sandra Lane (Public Health) at SU, Jerry Parks and Baohua Gu at Oak Ridge National Laboratory (Biogeochemistry), Lindsay Harrington and Dara Salley (Instrument Development) at Inficon in East Syracuse, and Sarwar Golam (Air Quality) at EPA.

The Syracuse Center of Excellence and the City of Syracuse are important stakeholders and institutional partners that have already invested in our previous and ongoing projects, and we will continue to work with them as part of this project. We will also build on previous work with the Syracuse City School District.

5) Increasing the use of ESF assets. Currently, Drs. Hassett and Mao run the ESF Atmospheric Observatory located on the rooftop of Jahn Laboratory at ESF. This station currently includes equipment for sampling PM, rain, and snow, as well as monitors for O_3, CO, and Hg. Data obtained from these monitors has been used to support numerous peer-reviewed manuscripts and successful graduate student theses. We would also take advantage of extensive, long-term, and ongoing studies of nitrogen cycling at HWF. The current availability of mercury monitors at both HWF and ESF's Syracuse gives us a starting point for evaluating sources, transport, and deposition of mercury across NYS. Additional ESF assets to be used for this proposal include an Hg analyzer for soil and tissue samples (A&TS), two Inductively Coupled Plasma instruments for metals analysis (A&TS), personal air quality monitors (Drs. Hassett and Mirowsky), and a 168-core server for modeling studies (Computing and Network Services).

6) Informing policy, enhancing ESF's reputation, and global impact. The research at ESF supported by this Discovery opportunity will provide the next generation of scientists and policy makers with a holistic understanding of the problems of air pollution and policy implementation**.** Investment in air pollution research would place ESF as a go-to institution for advanced education in the physical, chemical, ecological, and policy dimensions of air pollution at a time when treaties to reduce air pollution, such as the Minamata Convention on Mercury, are receiving global attention and funding, while EPA is pulling back on US regulations to curb pollutant levels.

7) New investments. For this proposal, we would purchase two $PM_{2.5}$ and BC monitors (one each for ESF and HWF), and one O_3 and CO monitor (one each for HWF only, as ESF already has these pieces of equipment). With these new pieces of equipment, the equipment at our two selected locations will match, allowing for direct comparisons of measurements between the sites. We would also obtain a controlled weighing chamber for PM filters for Jahn Lab. Drawing on EPA's pilot programs in community-based participatory monitoring, we will explore the use of low cost wireless sensors (in collaboration with SU's iSchool) for both citizen science and school-based initiatives that cultivate engagement. Graduate students would be funded for research to use existing and newly-acquired resources to generate preliminary data to strengthen research proposals.