



B O S C
Board of Scientific Counselors

**REVIEW OF
U.S. EPA OFFICE OF RESEARCH AND DEVELOPMENT'S
RESEARCH PROGRAMS**

Draft

BOSC Air, Climate, and Energy Subcommittee

Viney Aneja, Ph.D. (Chair)
North Carolina State University

Sandra Smith, MS (Vice Chair)
AECOM

Jeffrey Richard Arnold, Ph.D.
University of Washington

Elena S. Craft, Ph.D.
Environmental Defense Fund

Charlette A. Geffen Ph.D.
Pacific Northwest National Laboratory

Donna M. Kenski, Ph.D.
Lake Michigan Air Directors Consortium

Patrick Kinney, Ph.D.
Columbia University

Myron J. Mitchell, Ph.D.
State University of New York

Louie Rivers III, Ph.D.
North Carolina State University

Constance L. Senior, Ph.D.
ADA-ES, Inc.

Art Werner, Ph.D.
AMEC Environmental & Infrastructure

Jinhua Zhao, Ph.D.
Michigan State University

EPA Contact

Tim Benner, Designated Federal Officer

February 7, 2017

Disclaimer Text. This report was written by the Air, Climate, and Energy (ACE) Subcommittee of the Board of Scientific Counselors, a public advisory committee chartered under the Federal Advisory Committee Act (FACA) that provides external advice, information, and recommendations to the Office of Research and Development (ORD). This report has not been reviewed for approval by the U.S. Environmental Protection Agency (EPA), and therefore, the report's contents and recommendations do not necessarily represent the views and policies of EPA, or other agencies of the federal government. Further, the content of this report does not represent information approved or disseminated by EPA, and, consequently, it is not subject to EPA's Data Quality Guidelines. Mention of trade names or commercial products does not constitute a recommendation for use. Reports of the Board of Scientific Counselors are posted on the Internet at <http://www.epa.gov/bosc>.

CONTENTS

LIST OF ACRONYMS.....	4
INTRODUCTION.....	5
BACKGROUND.....	6
STRAP RESEARCH OBJECTIVES.....	7
CHARGE QUESTIONS AND CONTEXT.....	8
Charge Questions.....	8
CHARGE QUESTION 1.....	8
CHARGE QUESTION 2.....	8
CHARGE QUESTION 3.....	8
SUBCOMMITTEE RESPONSES TO CHARGE QUESTIONS.....	8
Subcommittee Feedback on Charge Questions.....	8
Charge Question 1.....	9
STRENGTHS.....	9
WEAKNESSES/SUGGESTIONS.....	10
Charge Question 2.....	11
Charge Question 3.....	14
Summary List of Recommendations.....	16
CHARGE QUESTION 1.....	16
CHARGE QUESTION 2.....	17
CHARGE QUESTION 3.....	17
CONCLUSIONS.....	18
APPENDIX A: MEETING AGENDA.....	19
APPENDIX B: MATERIALS.....	20

LIST OF ACRONYMS

ACE	Air, Climate, and Energy
BOSC	Board of Scientific Counselors
CSS	Chemical Safety for Sustainability
EM	Environmental Management
EPA	Environmental Protection Agency
HS	Homeland Security
NGO	Non-governmental Organization
NSF	National Science Foundation
OAR	Office of Air and Radiation
ORD	Office of Research and Development
RTP	Research Triangle Park
SHC	Sustainable and Healthy Communities
SSWR	Safe and Sustainable Water Resources
StRAP	Strategic Research Action Plan

INTRODUCTION

The U.S. Environmental Protection Agency (EPA) Office of Research and Development's (ORD) Air and Global Change (Climate) research programs have a long history of providing well-defined, scientifically sound products in support of regulatory and policy decisions. These two programs were merged in 2010 to form the Air, Climate and Energy (ACE) research program. The ACE program recognizes the inextricable linkages between air quality and climate and the need to address common issues in harmony. ACE also encompasses studies of energy use and decision-making regarding energy choices and the associated impacts on human health and the environment. This vision for integrated research on air, climate and energy sowed the seeds for expanded systems thinking and consideration of factors beyond the traditional technical and scientific bounds of our understanding.

At the same time, independent review bodies have repeatedly recommended to ORD and ACE that systems and solutions-oriented research cannot be fully achieved through technical or regulatory means alone. As ACE has matured and evolved in the last few years, interdisciplinary science¹ with a focus on public and environmental health goals has been embraced. It is the intent of the ACE program that research studies are not only published in scientific journals, but are designed and conducted in collaboration with partners and stakeholders who will use and ultimately translate research results into applications that improve public and environmental health.

The ACE Strategic Research Action Plan (StRAP) published in 2015 provides the program structure to meet the highest priority needs of the overall program and individual regional offices while simultaneously encouraging novel thinking to incorporate interdisciplinary solutions-oriented science.

In June 2015, the EPA Board of Scientific Counselors (BOSC) ACE Subcommittee had its initial face-to-face meeting with the ACE program where ACE provided a broad overview of its vision, structure, and core project-level descriptions. Partner offices also provided their perspectives on the ACE portfolio and supported the alignment with their priorities. A productive dialogue on ACE program balance and overall direction and vision followed, leading to Subcommittee recommendations. The perspectives and constructive commentary provided by the Subcommittee, in combination with the formal recommendations², are being addressed by ACE as the program continues to evolve. Among the recommendations was the need for ACE to seek ways to begin the integration of social science into its portfolio – especially if public health was to be nurtured as part of the environmental/public health mission.

Given resource limitations and the need to sustain ACE's traditional support to the development and implementation of air and climate policies, ACE undertook an alternate route to expanding work in social science. ACE enlisted a senior member of the EPA Office of Air and Radiation (OAR) staff trained in social science (economics) to lead the design of an ACE conceptual model for incorporating social science principles into the program fabric. ACE has made considerable progress in developing this conceptual model and in October 2016 asked the BOSC ACE Subcommittee for a focused review and discussion of the

.....
¹ "Interdisciplinary" is used in this context to mean connecting and integrating multiple disciplines – and their specific perspectives – in the pursuit on a common task.

² Review of U.S. EPA Office of Research and Development's Research Programs (PDF)
https://www.epa.gov/sites/production/files/2016-03/documents/bosc_report_02-29-2016_final.pdf

approaches described in the conceptual model to integrate social science³ with natural/physical science⁴ appropriately into the ACE portfolio.

BACKGROUND

In October 2016 ACE provided the BOSC ACE Subcommittee with review materials relating to their activities to integrate social science into ACE research programs, including a draft of the conceptual plan titled “Strengthening the Foundations for Interdisciplinary Social-Environmental Research in ACE”, and three charge questions to consider when reviewing the materials. Subsequently, the ACE Subcommittee:

1. Reviewed the draft conceptual plan and related materials (see Attachment A for list of materials);
2. Met with the ACE National Program Director and program staff on October 25-26, 2016 in Research Triangle Park (RTP), NC and listened to ACE presentations (see Attachment B for meeting agenda);
3. Deliberated as a group on the charge questions; and
4. Divided into three sub-groups to draft initial responses to each charge question.

The three Subcommittee small groups drafted specific responses to each charge question after the October 2016 meeting. The Chair and Vice Chair of the Subcommittee prepared an initial draft of the Subcommittee report based on charge question responses provided by the three small groups, circulated the initial draft report to all Subcommittee members, and asked for review comments. The report was revised based on Subcommittee member comments and discussions during a teleconference on December 2, 2016. The recommendations of the ACE Subcommittee in the draft report are based on material provided to us prior to the October 2016 meeting, presentations made during the day and a half meeting, and deliberations during the meeting and after the meeting in teleconference.

The draft report was submitted to the full BOSC Executive Committee, which met on January 11-13, 2017 in RTP, NC to review and discuss draft reports from each of five ORD BOSC subcommittees⁵. The Chair and Vice Chair of the ACE Subcommittee are members of the Executive Committee and participated in the meeting. The ACE National Program Director, Daniel Costa, Sc.D., was unable to attend the meeting. However, the ACE National Program Deputy Director, Dr. Alan Vette, and the Associate Director for Climate, Dr. Andrew Miller, were present. They and the members of the BOSC Executive Committee discussed the ACE Subcommittee draft report during the meeting, asked clarifying questions, provided perspective, and offered comments to the ACE Subcommittee Chair and Vice Chair. Dr. Bryan Hubbell, the author of the conceptual plan, was also present at the meeting and provided information on the ACE program’s continued progress to integrate social and natural sciences after the Subcommittee meeting in

.....
³ The conceptual model describes social science as a widely diverse set of areas of academic studies that include quantitatively focused disciplines such as economics and more qualitatively focused disciplines such as history and communication studies. Examples of social science disciplines that have been applied in the environmental and public health context include sociology, economics, anthropology, geography, demography, political science, decision science, behavioral science, risk communication, risk analysis, and urban planning. Appendix A of the conceptual model report provides a fairly comprehensive listing of social science disciplines and common definitions.

⁴ The conceptual model uses physical and natural sciences interchangeably to refer to non-social sciences. This charge question report uses “natural science” as a comprehensive term for scientific disciplines that deal with the physical world, such as biology, chemistry, geology, and physics. The definition as used in this report includes applied sciences such as engineering.

⁵ In addition to ACE, the other BOSC subcommittees are Chemical Safety for Sustainability (CSS), Homeland Security (HS), Safe and Sustainable Water Resources (SSWR), and Sustainable and Healthy Communities (SHC) (<https://www.epa.gov/bosc/about-bosc-subcommittees>).

October 2016. Dr. Hubbell has been named Senior Advisor for Social Sciences for ORD, and will be responsible for integrating social sciences into the other ORD research programs in addition to ACE.

Subsequently, the ACE Subcommittee Chair and Vice Chair revised the charge question report in response to questions and comments raised during the BOSC Executive Committee meeting, as well as the additional information provided during the meeting, and submitted this final report back to the Executive Committee for their final review.

STRAP RESEARCH OBJECTIVES

The *Air, Climate, and Energy (ACE) Strategic Research Action Plan, 2016 to–2019* outlines a research approach to address the U.S. Environmental Protection Agency’s (EPA’s) objectives and mandates to take action on climate change and improve air quality. We have made great gains over the past 45 years in combating air pollution and, as a result, the air is much cleaner. However, that progress is now threatened by climate change and is complicated by the life cycles of new energy technologies which have both benefits and potential adverse effects. To tackle these increasingly complex 21st century problems, innovative thinking and sustainable solutions are needed to ensure a healthy and prosperous environment. To address these challenges that cross science disciplines and media – air, water, and land – we need science-supported models and tools that allow us to make more informed decisions and understand the potential consequences of those decisions.

The ACE research program integrates air and climate science with better understanding of how energy science and engineering interconnect these domains. The ACE research program was developed with considerable input from Agency partners and outside stakeholders and interacts with the five other national research programs of EPA’s Office of Research and Development to address cross-cutting issues.

The ACE research program is structured to provide research results that address EPA priorities and mandates, meet partners’ needs, fill knowledge gaps, and complement broader efforts across the federal government, as well as research being conducted by the larger scientific community. The ACE research objectives are:

1. Assess Impacts—Assess human and ecosystem exposures and effects associated with air pollutants and climate change at individual, community, regional, and global scales;
2. Prevent and Reduce Emissions—Provide data and tools to develop and evaluate approaches to prevent and reduce emissions of pollutants into the atmosphere, particularly environmentally sustainable, cost-effective, and innovative multipollutant and sector-based approaches; and
3. Prepare for and Respond to Changes in Climate and Air Quality—Provide human exposure and environmental modeling, monitoring, metrics and information needed by individuals, communities, and governmental agencies to take action to prepare for and mitigate the impacts of climate change, and make public health decisions regarding air quality.

To achieve these objectives and address their scientific challenges, ACE research projects are organized into five interrelated topics: (1) Climate Impacts, Vulnerability, and Adaptation; (2) Emissions and Measurements; (3) Atmospheric and Integrated Modeling Systems; (4) Protecting Environmental Public Health and Well-being; and (5) Sustainable Energy and Mitigation. Each topic includes specific near- and long-term goals designed to yield solutions to address climate change and improve air quality. The ACE Strategic Research Action Plan, 2016–2019 (ACE StRAP), describes those topics and the overall structure and purpose of the ACE research program. The research results and innovative tools will support EPA’s

work to protect air quality and to meet broader EPA legal and statutory mandates in the face of a changing climate.

CHARGE QUESTIONS AND CONTEXT

Charge Questions

The Subcommittee was charged with three questions as follows:

Charge Question 1

The ACE program has developed a conceptual model for interdisciplinary research that brings together social and environmental sciences to address significant environmental challenges within the ACE research program. What are the strengths and weaknesses of this model in guiding ACE toward a more integrated social-environmental research program?

Charge Question 2

The ACE program is piloting several applications of the conceptual model, including an interdisciplinary problem formulation workshop on wildfire smoke risk communication and management that took place in September 2016. How can the ACE program make this approach more widely applicable to other aspects of the program such as 1) the Climate Roadmap and 2) distributed data collection, e.g., social and economic impacts of air quality sensors?

Charge Question 3

What are other viable, near-term opportunities for integrating social sciences, either within the ACE program or jointly with other ORD research programs that warrant discussion?

SUBCOMMITTEE RESPONSES TO CHARGE QUESTIONS

Subcommittee Feedback on Charge Questions

The ACE Subcommittee applauds EPA for its innovative approach that is provided in the conceptual model: “Strengthening the Foundation for Interdisciplinary Social-Environmental Research in ACE.” The application of this model entails an interdisciplinary approach that has broad implications and importance to the overall mission of EPA. The model provides new tools for addressing current and emerging environmental issues related to the air, climate and the extraction and use of energy. The application of the model should facilitate inclusion of a broader set of perspectives in addressing key environmental issues that include the participation of social and natural scientists and engineers.

Overall, the ACE Subcommittee found that the vision and objectives in the conceptual model for interdisciplinary research in social-natural science are clearly articulated and provide a sound conceptual approach with the potential to successfully integrate social sciences into the ACE portfolio. Additional progress has been made toward integrating social and natural sciences in the ACE program in the period of time since the Subcommittee met in October 2016. As noted in our more detailed comments below,

additional information on implementation and resource balance is requested to help evaluate the extent to which this model can be integrated into the ACE programs.

Subcommittee responses to each charge question follow below. The suggestions provided by the Subcommittee in response to each specific charge question are meant to complement and supplement ongoing and planned activities. The suggestions do not necessarily identify deficiencies in the program; but rather, in some cases the point of a suggestion is to endorse the importance of activities and initiatives that are already ongoing or planned and that the Subcommittee feels should receive continuing support.

Charge Question 1

We applaud ACE for its proposed innovative and forward-looking approach detailed so thoroughly in the conceptual model described in the report “Strengthening the Foundation for Interdisciplinary Social-Environmental Research in ACE.” The complexity of environmental issues within the ACE program demands the interdisciplinary approach described in the conceptual model, and we recommend that the document, in some form, be published in the open peer-reviewed literature. This publication would solidify ACE’s leadership in this area, as well as provide additional communication to the natural and social science communities. The journal review process would also provide feedback to ACE from the wider scientific community on the overall approach. As ACE moves forward, however, we urge the program to find ways to use the conceptual model for appropriate challenges, while at the same time maintaining focus on its base program functions that are also critical to the EPA and other communities (e.g., atmospheric modeling, emissions characterization) and to maintain the strength of those programs.

The Subcommittee has identified the following strengths and weaknesses of the current conceptual model:

Strengths

- Overall, the document is extremely well written with sufficient detail to fully describe and capture the nuances of the conceptual model. It gives careful attention to best practices of interdisciplinary collaboration and identifies a broad suite of social science disciplines that could be brought to bear on some of ACE’s specific and most important research interests.
- The approach is responsive to the directive to integrate social sciences into the ACE portfolio, and sets a direction that can be used by other parts of EPA to address this same challenge.
- The model emphasizes building networks of social and natural science experts within ACE, as well as within the entire EPA, thus providing a ‘skills marketplace’. Additional partnerships outside the Agency are also included as part of the model and plan.
- The network will provide education (on the social scientist expertise that exists within ORD and EPA and how the social sciences can enhance EPA research and other activities), with the aim to provide and facilitate dialogues within and among EPA projects and activities.
- The model recognizes the importance of a strong team facilitator to help insure the success of interdisciplinary social-natural science projects.
- The model emphasizes the value of using various logic flow diagrams (e.g., mind maps, dialogue maps, Dunker diagrams) as tools to encourage integrative, collaborative thinking during problem formulation and later stages of research.
- Dedicated funding and personnel for interdisciplinary research projects are acknowledged as necessary for successful implementation.
- The approach identifies newly available tools for data management, collection, and synthesis, and recognizes these tools as being important for successful implementation of this approach.

- The model recognizes that communication at the beginning of a project among social and natural scientists is key to harmonizing their efforts.
- The model capitalizes on existing ACE natural science strengths while bringing new social science expertise to environmental problems associated with air pollutants, climate change, and energy extraction and use. This collaborative and interdisciplinary approach positions the ACE program to address a broad suite of environmental issues and to reach a larger and more diverse body of users. This approach provides a mechanism for bringing specific ACE program results (for example, small sensor data) to a wider audience, providing diverse applications with potentially significant public health benefits.
- The model codifies a process that can be followed by the ACE program and other groups to address an array of problems with an interdisciplinary approach. The team approach using interdisciplinary facilitation allows for multiple voices to be heard and builds consensus throughout the process. The process truly sets the stage for integrative science, and provides new opportunities for partnership and collaboration among social and natural scientists, including those inside and outside of the EPA. The ACE program staff will likely find these additional opportunities professionally and personally rewarding. At the same time, the document acknowledges that this new approach may be initially difficult for some staff to embrace, and hence the importance for incentives and rewards to encourage participation.

Weaknesses/Suggestions

Some of the following points are not really weaknesses of the conceptual model, but suggestions for modification of the model to facilitate its application and usefulness.

- Strong leadership is needed at the problem formulation stage and beyond. Projects using this approach will need continuity and engagement from leaders throughout the process. Although the model recognizes the importance of a strong team facilitator to the success of interdisciplinary social-natural science projects (see strengths), it perhaps misses an opportunity to include early actions to actively identify and develop within ORD a cadre of team facilitators (both social scientists and natural scientists) specifically trained to lead integrated social-natural science projects.
- Interdisciplinary collaboration becomes more facile when it is supported by administration, an appropriately designed reward structure, and reduced transaction costs (information costs, team building costs, etc.). As ACE begins to implement this model, more thought will have to be given to these issues, most importantly on how to cultivate reward structures for interdisciplinary collaboration in creative ways outside of the formal performance evaluation process. This issue is discussed further in the response to Charge Question 3.
- Model implementation needs to be an iterative process with built-in mechanisms for modification, evolution, and feedback throughout all stages of the project from conceptualization to completion. Feedback loops should be made more explicit in the existing description and implementation of the model.
- The model suggests many commendable recommendations in the text of the report, such as considering more flexible work space (p. 58) and considering development of a blanket purchase agreement for social science support (p. 59); however, the specifics are not captured in the conclusions and recommendations.
- The model does not address the trade-offs necessary to integrate the new elements with existing elements under flat or declining funding and other resource constraints.

Putting the model into practice will require a cultural change in how ACE research takes place. EPA should articulate how the change will occur, and consider using organizational change management to support its implementation plans. It should be recognized that many ACE projects will continue as natural science/engineering research and that this interdisciplinary approach should not be forced to fit where it is not appropriate. Implementing the model must be done with care to ensure resources, including personnel, in existing base programs are appropriately managed and retained. As the model is further developed, the Subcommittee requests clarification on the specific guidelines the Agency will use to identify and select projects for this new integrated social-natural science approach.

Recommendations

The Subcommittee understands that the conceptual model is new, and that ACE is in the midst of its implementation. The ACE Subcommittee would like to stay involved in this on-going process in our capacity as an advisory committee, and requests that the program provide information to the Subcommittee in the future on projects that are selected for application of the integrated social-natural science approach, as well as progress in developing the social scientist network described in the conceptual model and determining the role of the network. Our recommendations at this time for enhancing the application of the conceptual model are:

Recommendation 1.1: Consider identifying and developing within ORD a cadre of team facilitators (both social scientists and natural scientists) specifically trained to lead integrated social-natural science projects.

Recommendation 1.2: Identify and clarify the iterative steps that will be used to further refine model application with respect to selection of projects for application of the integrated social-natural science approach, integration methodologies, data management, synthesis, and policy implications.

Recommendation 1.3: Continue to evaluate how the Agency will support cultural shifts within ACE and EPA more broadly for addressing environmental issues using this interdisciplinary approach. Agency support could include incentives for participation in interdisciplinary research that are discussed further in response to Charge Question 3.

Charge Question 2

EPA has made a good start in piloting the combined social and natural sciences conceptual model. Learning from these efforts can assist in establishing criteria for success moving forward. EPA might consider providing some criteria or guidelines to assist in problem formulation development that will serve as a guide for future interdisciplinary social and natural science research. Criteria that may be worth consideration in developing a problem statement, for example, include:

- magnitude of the problem (in terms of number of people impacted, area covered, hazard, risk);
- achievable benefits (health benefits, economic benefits, environmental benefits);
- resources, partnerships needed to complete interdisciplinary research project;
- timeliness to completion and ability for research to contribute to solving problems; and
- level of community interest/engagement. (Is it an issue of critical importance to the community?)

It will be useful to document the processes and results of successful interdisciplinary projects in ways that inform all phases of future research projects, starting with problem formulation. Documenting lessons learned from the wildfire workshop as well as evaluating new tools deployed as a result of the workshop

might be a good place to start. For example, in the wildfire workshop, one suggested outcome was the development and implementation of a smoke ready “app”. This app could include an early alert system that provides information on how members of the community, who will likely be impacted by wild fires, can protect their health. EPA could establish some metrics in advance of deploying the app to assess whether such an awareness campaign has achieved the goals of the interdisciplinary effort. An example of metrics for the app might include number of downloads of the app, percentage of users over certain geographic areas that may be at increased risk for wildfires, and retention of users of the app. These indicators could serve as a measure for the effectiveness of a public awareness campaign focused on wildfires and provide guidance to future public awareness campaigns in other areas.

In addition, there may be other mechanisms that EPA could employ to maximize the effectiveness in developing this conceptual model for interdisciplinary research, including:

- Selecting one staff member as the central point of contact to assist in project implementation;
- Putting together a list of resources (experts and documents, both internal and external from the Agency) to draw from to conduct the research;
- Emphasizing follow-up activities to the workshops to ensure that the network of researchers remain active; and
- Formally evaluating and assessing cross-programmatic workshops, with a particular focus on linking back to the goals and objectives of ACE/ORD. For instance, did the workshops contribute to the cultural change at ACE/ORD? How are ACE researchers involved? Will the workshop contribute to improved identification of the kind of social science capacity that is needed in the longer term, and how best to obtain that expertise?

Regarding potential applications in the climate domain, the 2016 Climate Roadmap assesses how ORD is currently or could in the future address the myriad ways in which climate change will impact EPA’s mission to protect the environment and human health. Work on climate change impacts, adaptation, and mitigation all involve interactions between natural and human systems, and thus represent ideal settings for innovative natural/social science projects. There are opportunities in particular to include environmental justice considerations in this research. We encourage ORD to develop additional pilot studies related to climate impacts, adaptation, and/or mitigation, and preferably involving two or more of these broad topics. In doing so, ORD may wish to identify areas in which EPA can have a unique role. Examples might include:

- quantifying mitigation/adaptation tradeoffs related to alternative transportation systems in cities that reduce both greenhouse gas and air pollution emissions, and encourage active transport such as biking or walking;
- investigating the benefits of urban greenspace for mitigation and adaptation, as well as health and wellbeing benefits;
- developing, applying and evaluating the value of downscaled climate and/or air quality projections for use by local decision makers, e.g., for planning related to disasters, water supply, land use, etc.;
- developing improved methods for assessing induced and/or avoided health impacts that result from mitigation and adaptation actions (with emphasis on vulnerable communities);
- assessing the benefits/impacts of natural gas extraction, including fracking, climate science, air quality, water quality, and health; and
- assessing the potential for collaboration with other federal agencies that may be working on similar initiatives and collaborate when possible.

An environmental justice perspective is important in each of the examples listed above and can provide one framework for integrating social and natural science research.

Enhancing the work of ACE by including more people trained and experienced with work on human dimensions of the applied research problems in the ACE portfolio will be more successful if intra- and extramural researchers perceive and gain the benefits of changing to a research approach with greater emphasis on social dimensions. Extramural researchers can be attracted to new or newly augmented funding programs that include integration of social science with traditional ACE research topics. As the research foci and funding sources and mechanisms change to incorporate these new social science elements, extramural researchers will likely adapt quickly to these new opportunities for collaboration.

Ensuring success of the augmented ACE research portfolio will also require direct involvement of intramural researchers. The draft roadmaps and piloted first versions of enhanced research projects shown to the ACE Subcommittee are excellent first steps. EPA has already begun a process to identify the knowledge, skills, and experience in ACE-related staff relevant to the new human and human population questions it will consider. This is a useful start and should be expanded as quickly as possible using lessons learned from the wildfire workshop and the Cardiopulmonary Health Workshop to encourage existing staff to consider where and how their skills could fit into interdisciplinary social and natural science research projects.

Attracting and retaining intramural staff in the application of this new model that integrates natural and social sciences is the most crucial aspect of its successful implementation. However, this could significantly increase workloads for intramural staff still absorbing recent and continuing changes to science administration in ACE and ORD. As noted in the response to Charge Question 1 and Recommendation 1.3 above, and further discussed in response to Charge Question 3, Agency support, including augmented incentives, will be important to encourage active participation by both intramural and extramural staff and partners. The issue of incentives and rewards that align with the emphasis on integrated social-natural science research is also important in the context of Charge Question 2, to help make the conceptual model approach more widely applicable to other aspects of the program.

Workshops should help facilitate the change in culture. Having the opportunity for staff to present in both internal and external professional forums and brainstorm on current work would facilitate dissemination of information as well as generate new ideas. In addition, using community monitoring grants would provide a mechanism to collect information and engage with communities in real-time and provide a two-way communication opportunity to share insights about findings. In addition, community engagement has the added benefit of offering a way to promote and share research findings to the public at large, a key element to the success of an interdisciplinary program of this nature.

The Subcommittee understands that ORD carefully considers on a routine basis the tradeoffs related to making shifts in research emphasis, and notes that impacts of greater inclusion of social science on research in the more traditional environmental sciences is a concern. Utilizing staff, who can draft, execute, evaluate, and report on new social science research and interface with natural sciences, in an environment of budget and other research constraints, may require some reduction in the natural science agendas performed by ACE and ORD. The Subcommittee encourages EPA to continue to carefully evaluate the trade-offs required to add and fund entirely novel aspects of social science and human population dimensions more generally to the continuing and future-planned applied physical and biological science, which is the hallmark of ACE research in support of EPA's missions.

Recommendations

ORD's piloting of the new conceptual model for incorporating social science into the ACE mission provides a valuable foundation for future expansion. We encourage ORD to develop additional pilot studies and to continue to build on lessons learned in problem formulation, outcomes, and evaluation. There are likely to be excellent opportunities for expansion in the domain of climate and air pollution impacts and adaptation research (topics where ORD may have a unique role are listed in the text), and in applying environmental sensors to track and evaluate environmental change. As noted in Recommendation 1.3 above and discussed further in response to Charge Question 3, Agency support, including explicit incentives, will be important to encourage participation by both intramural staff and extramural partners. We have two specific recommendations to help make the conceptual model approach more widely applicable to other aspects of the ACE program:

Recommendation 2.1: Document lessons learned (what worked and what didn't work) from the wildfire smoke health risk workshop and other pilot applications of the conceptual model. As these lessons are learned, consider developing criteria or guidelines for problem formulation and evaluation, and other phases of integrated social-natural science projects, which can serve as a guide for future interdisciplinary social-natural science research. Some example criteria that may apply when developing a problem statement are provided in the text.

Recommendation 2.2: The Subcommittee encourages EPA to develop additional pilot studies related to climate impacts, adaptation, and/or mitigation, and preferably involving two or more of these broad topics.

Charge Question 3

When social sciences are integrated into ACE projects, they must meet the same level of rigor as the natural sciences. One near-term opportunity to encourage the success of the integration effort is to identify and apply metrics and expertise in reviewing the quality of social science research. The Subcommittee suggests that ACE evaluate the metrics that have been developed by other agencies that have a longer history of sponsoring social science research. For example, ACE might bring in the expertise of the National Science Foundation (NSF) Social, Behavioral, and Economic Sciences Directorate to develop metrics and quality assurance measures that apply in the context of the integrated research that ACE plans to conduct.

A major attribute of ACE scientists and engineers is their ability to address problems. Partnering at the problem formulation stage with the right team is important to help ACE researchers integrate the social sciences into new and existing programs. For example, problem formulation teams can include stakeholders and organizations that have experience with interdisciplinary team projects. These teams should examine the intersection of natural environments, built environments, and social systems. Potential partners will depend on the nature of the problem; some examples include:

- Nitrogen deposition from the air affects local watersheds and adds to the critical nitrogen load of an ecosystem; partners could include EPA's water and air program offices, state and municipal agencies, non-governmental organizations (NGOs), academia; individual with social science training should support the problem formulation process in terms of helping resolve conflicting goals.
- Acceptance of renewable energy in specific communities should involve collaboration between engineers who understand the technologies, behavioral economic criteria, the operation of local governments (this topic should be pursued in partnership with the Department of Energy).

As discussed in response to Charge Questions 1 and 2, ACE researchers should be incentivized to engage and present at interdisciplinary conferences. This might be achieved through publicizing a wider range of conferences within ACE and providing supplemental travel funds specifically targeted for staff participation at selected interdisciplinary conferences. The Subcommittee views such incentives as a near-term opportunity for advancing the integration of social and natural sciences within ACE.

Creative incentives for less formal collaborations with outside researchers in the social sciences would provide positive engagement for ACE researchers at relatively low or no additional cost and enhance their ability to tackle interdisciplinary problems. Examples of collaborative activities that could be implemented in the near term include:

- Running models with other researchers' data, synthesizing the results including other researcher's results, and finally developing joint publications.
- Offering course credit for university students who carry out short-term collaborations with ACE researchers.
- Making use of current opportunities that engage graduate students and post-doctoral researchers to explore interdisciplinary research problems.
- Targeting natural science and social science faculty and other non-academic experts to attend ACE workshops and possibly take on advisory roles.
- Becoming more familiar with interdisciplinary programs at other science-based federal agencies.

The Subcommittee also suggests that ACE hold regular interdisciplinary seminars organized around topics that are similar to projects or priorities in ACE, with a focus on bringing in project staff in addition to team leaders. ACE researchers would benefit from greater exposure to how interdisciplinary teams have solved problems.

The conceptual model recognizes the value of early success. The Subcommittee encourages implementation of at least some elements of the conceptual model quickly to help initiate the process. The example provided by the wildfire workshop is a good start to organize interdisciplinary teams involving ACE researchers and social scientists (either within or outside of EPA). It is important that ACE track and document activities associated with this initiative and evaluate performance for feedback and future improvement. Ideally, ACE can define where EPA can make a unique contribution to the challenges of interdisciplinary natural and social science research.

As projects are piloted within ACE (e.g., the wildfire workshop), the outcomes (what worked and what didn't work) should be communicated more broadly within ACE in an interactive workshop format, as discussed in response to Charge Question 2 and Recommendation 2.1.

The ACE Subcommittee also feels it is important to establish communication outlets and expand existing networks to include:

- Training pre-college teachers in the importance of interdisciplinary projects, so that high school students are exposed to the concept of interdisciplinary approaches to environmental issues.
- Having discussions with other agencies, universities, and organizations that are good at supporting interdisciplinary collaboration.

Finally, interdisciplinary projects should be selected with care. ACE should avoid force fitting social scientists into purely natural science projects both to insure that funds are used wisely and to minimize the potential for failure.

Recommendations

Partnering at the problem formulation stage with the right team is important to help ACE researchers integrate the social sciences into new and existing programs. Success in interdisciplinary team building rests on exposing ACE researchers to a broader range of areas of knowledge and approaches than they may have previously experienced. Furthermore, incorporation of metrics and expertise in reviewing the quality of social science research is critical to maintaining the high quality of work product for which ACE is known. Finally, interdisciplinary projects should be selected with care. ACE should avoid force fitting social scientists into purely natural science projects both to use funding wisely and to avoid the potential for failure. In particular, the Subcommittee considers the following recommendations to be viable, near-term opportunities to encourage successful integration of social and natural sciences in ACE:

Recommendation 3.1: Evaluate metrics that have been developed by other agencies with a longer history of sponsoring social science research with the aim to develop metrics and quality assurance measures that apply in the context of the integrated research that ACE plans to conduct. For example, ACE might collaborate with the NSF Social, Behavioral, and Economic Sciences Directorate to develop appropriate metrics.

Recommendation 3.2: Create incentives for ACE researchers to engage and present at interdisciplinary conferences. This might be achieved through publicizing a wider range of conferences within ACE and providing supplemental travel funds specifically targeted for staff participation at selected interdisciplinary conferences.

Recommendation 3.3: Develop new avenues (with appropriate incentives) for exposing ACE researchers to interdisciplinary projects, such as conferences, in-house seminars, and less formal collaborations.

Summary List of Recommendations

Charge Question 1

The Subcommittee understands that the conceptual model is new, and that ACE is in the midst of its implementation. The ACE Subcommittee would like to stay involved in this on-going process in our capacity as an advisory committee, and requests that the program provide information to the Subcommittee in the future on projects that are selected for application of the integrated social-natural science approach, as well as progress in developing the social scientist network described in the conceptual model and determining the role of the network. Our recommendations at this time for enhancing the application of the conceptual model are:

- **Recommendation 1.1:** Consider identifying and developing within ORD a cadre of team facilitators (both social scientists and natural scientists) specifically trained to lead integrated social-natural science projects.
- **Recommendation 1.2:** Identify and clarify the iterative steps that will be used to further refine model application with respect to selection of projects for application of the integrated social-natural science approach, integration methodologies, data management, synthesis, and policy implications.
- **Recommendation 1.3:** Continue to evaluate how the Agency will support cultural shifts within ACE and EPA more broadly for addressing environmental issues using this interdisciplinary approach. Agency support could include incentives for participation in interdisciplinary research that are discussed further in response to Charge Question 3.

Charge Question 2

ORD's piloting of the new conceptual model for incorporating social science into the ACE mission provides a valuable foundation for future expansion. We encourage ORD to develop additional pilot studies and to continue to build on lessons learned in problem formulation, outcomes, and evaluation. There are likely to be excellent opportunities for expansion in the domain of climate and air pollution impacts and adaptation research (topics where ORD may have a unique role are listed in the text), and in applying environmental sensors to track and evaluate environmental change. As noted in Recommendation 1.3 above and discussed further in response to Charge Question 3, Agency support, including explicit incentives, will be important to encourage participation by both intramural staff and extramural partners. We have two specific recommendations to help make the conceptual model approach more widely applicable to other aspects of the ACE program:

- **Recommendation 2.1:** Document lessons learned (what worked and what didn't work) from the wildfire smoke health risk workshop, and other pilot applications of the conceptual model. As these lessons are learned, consider developing criteria or guidelines for problem formulation and evaluation, and other phases of integrated social-natural science projects, which can serve as a guide for future interdisciplinary social-natural science research. Some example criteria that may apply when developing a problem statement are provided in the text.
- **Recommendation 2.2:** The Subcommittee encourages EPA to develop additional pilot studies related to climate impacts, adaptation, and/or mitigation, and preferably involving two or more of these broad topics.

Charge Question 3

Partnering at the problem formulation stage with the right team is important to help ACE researchers integrate the social sciences into new and existing programs. Success in interdisciplinary team building rests on exposing ACE researchers to a broader range of areas of knowledge and approaches than they may have previously experienced. Furthermore, incorporation of metrics and expertise in reviewing the quality of social science research is critical to maintaining the high quality of work product for which ACE is known. Finally, interdisciplinary projects should be selected with care. ACE should avoid force fitting social scientists into purely natural science projects both to use funding wisely and to avoid the potential for failure. In particular, the Subcommittee considers the following recommendations to be viable, near-term opportunities to encourage successful integration of social and natural sciences in ACE:

- **Recommendation 3.1:** Evaluate metrics that have been developed by other agencies with a longer history of sponsoring social science research with the aim to develop metrics and quality assurance measures that apply in the context of the integrated research that ACE plans to conduct. For example, ACE might collaborate with the NSF Social, Behavioral, and Economic Sciences Directorate to develop appropriate metrics.
- **Recommendation 3.2:** Create incentives for ACE researchers to engage and present at interdisciplinary conferences. This might be achieved through publicizing a wider range of conferences within ACE and providing supplemental travel funds specifically targeted for staff participation at selected interdisciplinary conferences.
- **Recommendation 3.3:** Develop new avenues (with appropriate incentives) for exposing ACE researchers to interdisciplinary projects, such as conferences, in-house seminars, and less formal collaborations.

CONCLUSIONS

The ACE Subcommittee applauds EPA for its innovative approach that is provided in the conceptual model: “Strengthening the Foundation for Interdisciplinary Social-Environmental Research in ACE.” The application of this model entails an interdisciplinary approach that has broad implications and importance to the overall mission of EPA. The model provides new tools for addressing current and emerging environmental issues related to the air, climate and the extraction and use of energy. The application of this model should facilitate inclusion of a broader set of perspectives in addressing key environmental issues that include the participation of social and natural scientists and engineers.

APPENDIX A: MEETING AGENDA

TIME	TOPIC	PRESENTER
Tuesday, October 25, 2016		
8:00-8:30	Registration	
8:30-8:45	Welcome, Introduction, and Opening Remarks	Viney Aneja, Chair
8:45-9:00	DFO Welcome	Tim Benner
9:00-10:45	Program Update and Discussion	Dan Costa
10:45-11:00	Break	
11:00-11:30	Review of Charge Questions	Dan Costa Subcommittee
11:30-12:30	Lunch	
12:30-1:30	Presentation on ACE's conceptual model Discussion	Bryan Hubbell Subcommittee
1:30-2:30	Presentation on Smoke Communication Workshop Presentation on Cardiopulmonary Health Workshop Discussion	Bryan Hubbell Wayne Cascio Subcommittee
2:30-2:45	Break	
2:45-3:15	Presentation on Connections with SHC program Discussion	Andrew Geller Subcommittee
3:15-4:45	Discussion of Responses to Charge Questions	Subcommittee
4:45-5:00	Wrap-up and Adjourn	
Wednesday, October 26, 2016		
8:30-9:30	Subcommittee Discussion EPA Response to Subcommittee Questions	Subcommittee Dan Costa
9:30-9:45	Public Comments (if any)	
9:45-12:00	Subcommittee Discussion and Writing	Subcommittee
12:00-12:15	Wrap-up and Adjourn	

APPENDIX B: MATERIALS

Material Provided in Advance of the Meeting

- *Environmental Management* (EM) article titled “Human Problems Warrant Human Solutions: How EPA is integrating social and environmental science to help solve the most challenging and consequential problems related to air, climate, and energy”
- Paper titled “Strengthening the Foundation for Interdisciplinary Social Environmental Science in ACE”
- Executive Summary of the Paper titled “Strengthening the Foundation for Interdisciplinary Social Environmental Science in ACE”
- EHP Article (in review): “The Social Life of Sensors: Research Directions for Understanding Social Drivers and Impacts of the Use of Air Quality Sensors”
- DRAFT Climate Roadmap (FYI ONLY: this will be reviewed by the BOSC EC)
- DRAFT Climate Roadmap Annual Report (FYI ONLY: this will be reviewed by the BOSC EC)

Links to additional information:

- BOSC EC Report <https://www.epa.gov/bosc/review-us-epa-office-research-and-developments-research-programs>
- EPA response to the BOSC EC Report <https://www.epa.gov/bosc/epa-response-review-office-research-and-developments-research-programs>