WORKSHOP REPORT

March 10th, 2017

U.S. Environmental Protection Agency Workshop

Wildfire Smoke and Health Risk Communication: Integrating Social and Natural Sciences to Improve Risk Communication and Management Strategies in Impacted Communities

EPA/600/R-17/076

U.S. Environmental Protection Agency
Main Campus, Auditorium C111 A and B
Research Triangle Park, NC

September 22-23, 2016

Table of Contents

Executive Summary

Recognizing the risks from exposure to smoke from wildland fires, the U.S. Environmental Protection Agency (EPA) and other federal and state agencies have produced a number of documents to inform efforts to communicate wildfire smoke risks and to provide actions that communities and individuals can take to reduce risks from smoke exposures. These guides, including "Wildfire Smoke: A Guide for Public Health Officials," provide helpful information to states and communities during wildfire smoke events. The Air, Climate, and Energy (ACE) research program in EPA's Office of Research and Development (ORD) is already engaged in research to evaluate the utility of current communication strategies and identify improvements to increase the likelihood that individuals will adopt preventative health behaviors and reduce

the public health burden of smoke exposures. Given the growth of technologies that can be used to deliver personalized information on air quality conditions and health risks, there are opportunities to explore development of technologies to enhance communication of risks and inform individual and/or community level health-protective actions. As future research efforts are considered, including the under-development SmokeReady[1] study—which uses a mobile application and a crowdsourcing approach to the study of health effects of wildfire smoke exposure and to determine effective communication strategies to use to educate those impacted about health risks—the ACE program determined that it would be beneficial to convene a workshop to allow for different stakeholders and social and natural scientists to discuss promising research directions.

The EPA's ACE research program and Office of Air Quality Planning and Standards (OAQPS) co-sponsored a "Wildfire Smoke Health Risk Management and Communication Workshop" with the goal to identify opportunities for research and technological solutions that could improve health-risk communication strategies, increase health-protective behaviors, and reduce the public health burden during wildfire smoke episodes. We designed the workshop to engage participants in interdisciplinary problem formulation and to develop a shared and multidimensional understanding of 1) the nature of the public health problem associated with smoke exposures that reflects community attributes and experiences, and 2) what types of information and actions related to health risk communication and management might be appropriate for scientific evaluation. This workshop piloted an interdisciplinary and multi-stakeholder social-environmental research problem formulation approach to improve understanding of knowledge gaps and generate ideas to meet the workshop objective.

An organizing team comprised of EPA staff in the ORD and OAQPS planned and implemented the workshop, and are the primary authors of this report. As members of this organizing team, we selected participants to represent various backgrounds including social and environmental science disciplines, as well as stakeholders representing affected communities and decision-making agencies. Prior to the workshop, we invited participants to engage in a mind mapping (a visually structured way of organizing how an individual conceptualizes an issue) exercise on problem formulation surrounding smoke health risk communication reflecting their background and expertise. Based on the consolidation of individual mind maps into a master mind map, we identified five key focal areas which were used to guide the format of the workshop discussion during breakout groups. These five areas included:

- Assessment of risks from exposure to wildfire smoke
- Coordination between agencies and stakeholders
- Government agency interventions to mitigate exposures and health effects
- Improving air quality awareness – message content
- Improving air quality awareness – message delivery mechanisms

[1] Study name has been changed from "SmokeReady" to "Smoke Sense".

The first day discussion sessions focused on developing problem statements for the five focal areas that identified knowledge gaps that prevent realization of the desired state of highly effective risk communication and management during smoke events. The second day discussions focused on opportunities to bridge those gaps. The context for discussion across various levels of engagement and expertise was provided through participant presentations on community engagement, multi-state/regional/federal engagement, and research perspectives, as well as through poster presentations on Day 1 of the workshop. The second-day breakout group discussions focused on identifying potential research and technology development directions that can help bridge the gaps and lead to solutions. These included:

- Application of research from the social sciences to include the voices of underserved populations in the development and delivery of messages – building trust in impacted communities
- Identification of barriers (knowledge, attitudes, resources) to protective action, and new methods and technologies that incorporate social as well as technological information to fill in gaps in information to craft better messages
- Evaluation of the use of additional information to supplement the AQI during wildfire smoke episodes, e.g. sensors
- Evaluation of the effectiveness of interventions – metrics for determining who received what messages, actions taken, public health benefit;
- Design of a monitoring network that would better capture wildland fire smoke emissions and a process for disseminating information from the network;
- Development of finer scale modeling of smoke and integration with monitoring data;
- Additional studies of health impacts of smoke, both acute and chronic exposures;
- Development of an online resource to house and share communication materials that have worked.

The workshop was a pilot of the EPA social-environmental research problem formulation framework. This framework brings together scientists from a wide range of social and natural sciences with a wide range of stakeholders. The approach is designed to be participant driven and to encourage engagement among social and environmental scientists and stakeholders toward the objective of improved communication and management of the risks from wildland fire smoke exposures. To provide opportunities for active participation, we limited participation to a total of 67 attendees: active participants with expertise in social and natural science disciplines, and different stakeholder perspectives (e.g. federal agency, tribe, state, etc.), facilitators, note-takers, and observers. As part of this pilot, workshop observers applied ethnographic techniques to evaluate the effectiveness of this interdisciplinary process of problem formulation by observing: the nature of participant engagement and interactions, including the “mood” of the individuals and groups; the effectiveness of communications between different fields of expertise and frames of reference; and group dynamics and interactions. Initial insights from the ethnographic analyses indicate that the personalities within groups can, many times, be one of the strongest factors steering the dynamic of a group. Learned gender roles played a part in the tone of the discussions (degree of involvement, level of

agreement vs. disagreement, sitting positions). In addition, the groups who had a large majority of individuals who were already familiar with each other before the conference were able to cooperate much faster than the groups that did not.

This report summarizes in detail, the activities and discussions during the EPA sponsored workshop titled "Wildfire Smoke and Health Risk Communication: Integrating Social and Natural Sciences to Improve Risk Communication and Management Strategies in Impacted Communities." In addition to the report, the workshop organizing team will present results and lessons learned to wider audience during conferences, post-workshop webinars and prepare one or more journal articles. The team will also prepare a journal article focused on the workshop process as a framework to be considered for other environmental topics. Additionally, the team delivered an overview to EPA's Air, Climate, and Energy National Program Board of Scientific Councilors Subcommittee. The organizing team is also considering options for an online repository for successful wildland fire smoke risk communication materials.

DISCLAIMER

This document reflects the proceedings of the workshop, including presentations made by invited speakers, the discussions consequent to those presentations, and summaries of the individual breakout groups. Statements included in this document reflect discussions among participants in the workshop and should not be interpreted as official views of the U.S. Environmental Protection Agency.

Introduction and Overview

The U.S. Environmental Protection Agency (EPA) held a "Wildfire Smoke Risk Communication and Management Workshop" on September 22-23, 2016 in Research Triangle Park, North Carolina, hosted by the Office of Research and Development (ORD) Air, Climate, and Energy Program (ACE), the ORD National Health and Environmental Effects Research Lab (NHEERL) and the Office of Air Quality Planning and Standards (OAQPS). The objective of the workshop was to identify opportunities for research and technological solutions that will improve health-risk communication strategies, increase health-protective behaviors, and reduce the public-health burden during wildland fire smoke episodes. To reach this goal, the objective of the workshop was to engage participants in interdisciplinary, multi-stakeholder problem formulation to develop a shared and multidimensional understanding of 1) the nature of the public health problem associated with smoke exposures that reflects community attributes and experiences, and 2) what types of information and actions related to risk communication and management might be appropriate for future scientific evaluation.

This workshop served as an opportunity to pilot a social-environmental research framework developed by ORD-ACE, and brought together experts from a wide variety of social and environmental science disciplines, as well as stakeholders representing affected communities

and decision-making agencies. The workshop provided an opportunity to develop broad problem statements around critical elements of the smoke risk communication problem, and also led participants in identifying research and development opportunities to address key gaps identified in those problem statements. As part of this pilot, workshop observers applied ethnographic techniques to evaluate the effectiveness of this interdisciplinary process of problem formulation by observing the nature of participant engagement and interactions, including the "mood" of the individuals and groups, effectiveness of communications between different fields of expertise and frames of reference, and group dynamics and interactions. We will use the results from these observations to help develop "best practices" for future interdisciplinary, multi-stakeholder problem formulation workshops.

This report documents the proceedings and activities of the workshop. An organizing team comprised of EPA staff in ORD and the Office of Air Quality Planning and Standards planned and implemented the workshop, and are the primary authors of this report. In this report, we describe the motivations for the workshop, the workshop planning process and pre-workshop activities, the presentations and discussions during the two days of the workshop, and the initial outputs of the workshop, including problem statements for the five focal areas of the workshop, and a set of potential research and technology development directions.

Motivation for This Workshop

The motivation for this workshop was the growing risks posed by exposures to smoke from wildland fires. In two recent reviews of the health impacts of wildland fire smoke[2], over 60 scientific studies were identified. Health effects known or suspected to be caused by wildfire smoke included: all-cause mortality, asthma and chronic obstructive pulmonary disease exacerbations, bronchitis, pneumonia, childhood respiratory disease, cardiovascular outcomes, adverse birth outcomes, anxiety, and symptoms such as eye irritation, sore throat, wheezing, and coughing. As well, exposure to smoke is likely to be on the rise as recent research has demonstrated that the frequency, extent, and severity (level of damage) of large wildland fires is increasing. This rise is partially due to climate change, but also reflects past and current decisions related to management of wildfire risk factors such as build-up of fuel loads, and wildfire suppression (U.S. EPA, 2014).

Recognizing the risks from exposure to smoke from wildland fires, the EPA and other federal and state agencies have produced a number of documents to inform efforts to communicate health risks related to wildfire smoke and to provide actions that communities and individuals can take to reduce their risks from smoke exposures. These include "Wildfire Smoke: A Guide for Public Health Officials", jointly produced by the U.S. EPA, the U.S. Forest Service, the U.S. Centers for

[2] Liu, J. C., Pereira, G., Uhl, S. A., Bravo, M. A., & Bell, M. L. (2015). A systematic review of the physical health impacts from non-occupational exposure to wildfire smoke. *Environmental research*, *136*, 120-132.
Reid, C. E., Brauer, M., Johnston, F. H., Jerrett, M., Balmes, J. R., & Elliott, C. T. (2016). Critical review of health impacts of wildfire smoke exposure. Environ Health Perspect, 124(9), 1334-43.

Disease Control and Prevention, and the California Air Resources Board, revised in May 2016. There are also online resources, including the AirNow Fires: Current Conditions page (https://www.airnow.gov/index.cfm?action=topics.smoke_wildfires) and the Air Quality Index (AQI). In addition, many other communication and outreach programs are prepared and implemented at the community and state levels. While these guides provide helpful information to states and communities during wildfire smoke events, there has been little evaluation of their effectiveness in protecting public health during smoke events.

The management of risks from wildfire smoke remains a challenge that crosses natural and social science disciplines (e.g., air quality monitoring, forest science, epidemiology, economics, sociology, etc.) and multiple levels of stakeholders (individuals, local communities, state and regional planners, federal agencies). This challenge presents an opportunity for research into how information on smoke conditions and potential interventions to reduce exposures and health effects can be communicated effectively to at-risk populations. Given the growth of technologies that can be used to deliver personalized information on air quality conditions and health risks, there are opportunities to explore development of technologies to enhance communication of risks and inform individual and/or community level health-protective actions.

The ACE research program in ORD is already engaged in research to determine the utility of current communication strategies and identify new ones to increase the likelihood that individuals will adopt preventative health behaviors and reduce the public health burden of smoke exposures. One of those elements is the SmokeReady[3] study, which uses a mobile application and a crowdsourcing approach to the study of health effects of wildfire smoke exposure and to determine effective communication strategies to use to educate those impacted about health risks. In developing the design for this research, there was a desire to apply the insights from behavioral and social sciences to improve risk communication by: adapting to important elements such as awareness, accessibility, usability, and understanding of health risk messages; understanding how social context affects reception of risk information and ability to respond; and incorporating technological and scientific advances in smoke forecasting into the research. The principle investigator of this research recognized the opportunity to engage in broader problem formulation to inform the research design by bringing together social and natural scientists in a workshop. This workshop provided an excellent opportunity to pilot the principles of interdisciplinary, multi-stakeholder problem formulation as described in the ORD-ACE report "Strengthening the Foundation for Interdisciplinary Social-Environmental Research in ACE" (Hubbell, 2016). The report states:

> A successful interdisciplinary approach to addressing a selected socio-environmental problem will be one that starts with interdisciplinary problem formulation. Senior ACE leaders should commit to involving both social and natural scientists from the very beginning of the research process, or the level of commitment from both families of disciplines to the endeavor will be diminished. It is also critical to engage decision

[3] Study name has been changed from "SmokeReady" to "Smoke Sense".

makers, policy analysts, and communities who will be engaged in using the results of the research.

Thus, the workshop format followed those principles by involving a wide array of disciplines across the social and natural sciences, and engaging multiple levels of stakeholders who are likely to utilize the research results.

Workshop Participants

The workshop was by invitation only, with invitees carefully selected to reflect a range of social and natural science expertise, as well as a range of stakeholder perspectives. Participation was limited to under 50 active participants[4] in order to provide greater opportunities for interactions among participants and allow all participants to play active roles in the discussions. Participants provided their areas of expertise, experience with fire related smoke, level of engagement, and publications or other resources for the workshop.

The workshop had four types of participants: active participants with expertise in social and natural science disciplines and different stakeholder perspectives (e.g. federal agency, tribe, state, etc.), facilitators, note-takers, and ethnographic observers. There were a total of 67 attendees, with 42 active participants, 20 facilitators/note-takers/observers, and 5 additional non-participating attendees. In addition, the keynote speaker from day 2 also participated after his presentation in a breakout group. Active participants in the workshop represented many different backgrounds: toxicology, public health, emergency medicine, cardiology, epidemiology, statistics, exposure assessment, climate science, atmospheric modeling, indoor air quality, ambient air monitoring, risk communication, health and science communication, stakeholder engagement, anthropology, sociology, decision sciences, and economics. A wide range of stakeholder groups were also represented, including several groups within EPA (ORD, Office of Air and Radiation, and EPA regions 7, 8, 9, and 10), other federal agencies (Centers for Disease Control, National Institutes of Environmental Health Science, US Forest Service, and National Oceanographic and Atmospheric Administration), the Colville Tribe, State Agencies (WA, NM, CA, ID), universities (University of North Carolina, Oregon State University, Colorado State University, North Carolina State University, Duke University, Rutgers University, Ohio State University, University of Oxford), medical practitioners, and technology developers.

The final balance of participation across areas of expertise and areas of engagement is presented in Figure 1. A few perspectives, such as community level public health expertise, were minimally represented. However, across each expertise category and stakeholder level, there were at least 7 participants representing that perspective.

[4] Due to several cancellations, the actual number of active participants ended up at 42.

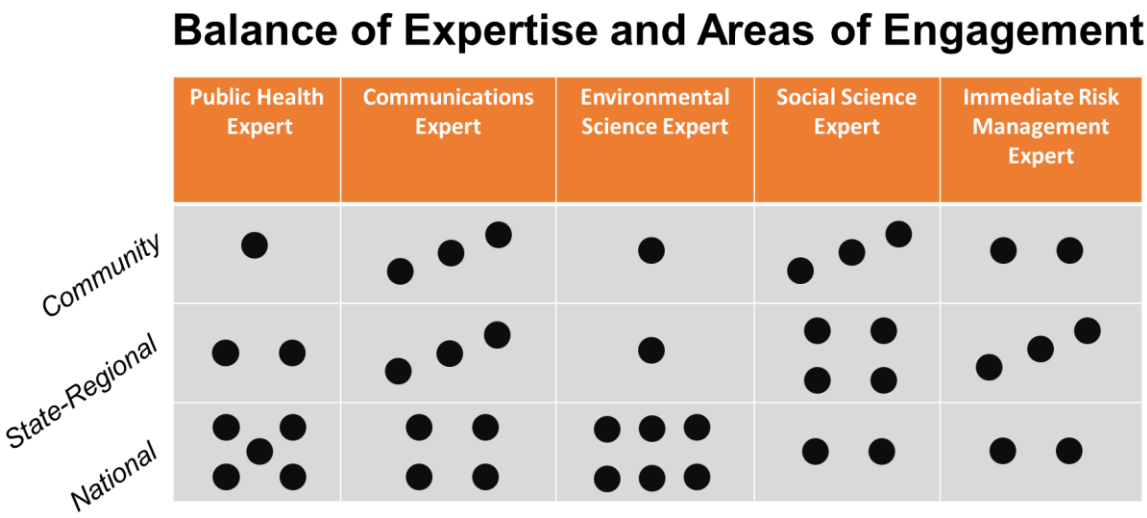


Figure 1. Interdisciplinary and Level of Engagement Balance of Workshop 'Active' Participants. Each dot represents one of the 42 active participants.

Overall Workshop Structure

The overall workshop design had three main components: pre-, during-, and post- workshop activities (Figure 2).

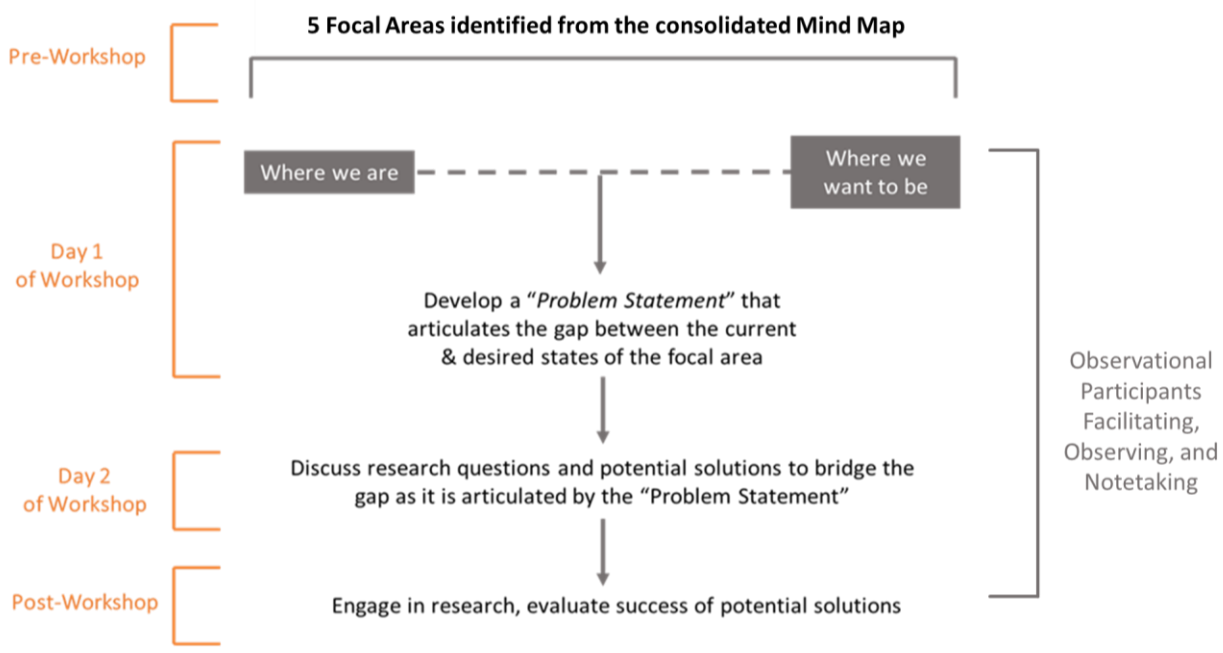


Figure 2. Overall Structure of the Wildfire Risk Communication and Management Workshop

We conducted several pre-workshop activities to both inform the structure of the workshop, and to prepare workshop participants for the problem formulation exercise. The key pre-workshop activities for participants were to complete a pre-workshop questionnaire and construct a mind map (a tool for visualizing the elements of complex problems) around the main topic of wildfire smoke risk communication and management. We asked participants to submit their mind maps approximately two months before the scheduled two-day workshop. We then consolidated the individual maps into one "master" mind map and shared it with workshop participants one month prior to the workshop.

We structured the two-day workshop to achieve two specific goals. The goal of the first day was to develop problem statements for each of the five focal areas identified through the mind-mapping exercise. The goal of the second day was to identify potential research and development opportunities to address the knowledge gaps identified in the problem statements developed on day one (Figure 2.).

Prior to the traditional welcoming and logistical presentations, the workshop opened with a talk by Kris Ray. Mr. Ray is an air quality manager for the Confederated Tribes of the Colville Reservation in Nespelem, WA. He established context for the workshop participants and created an important connection to the public health and welfare significance of the research topics, based on his personal experiences dealing with the consequences of the 2015 "monster fires" across the Northwest. Next, to lay a foundation for the breakout group discussion, 14 of the participants provided a range of perspectives through a set of short (10 minute) contextual presentations covering different levels of stakeholder engagement and areas of expertise, grouped into community engagement, multi-state/regional/federal engagement, or research perspectives. These presentations led into the first day's breakout groups focused on developing problem statements. On the second day, Ana Rappold (EPA ORD) and Jason Geer (The Weather Company) provided two opening presentations related to emerging technologies that could be used to improve risk communication. These were followed by a keynote talk by Greg Fishel (WRAL-TV), a nationally recognized meteorologist at a Raleigh, NC network television station, on his experiences in communicating risk information related to weather events. These talks set the stage for the second day breakout groups on research and technology development opportunities.

The workshop ended with a summary of the potential research and technology development opportunities and a discussion of potential follow-up activities. On-going post workshop activities include the summarizing of workshop processes and activities, and continuing conversation and collaboration with workshop participants. Workshop summaries, including this report, will be disseminated among participants and short papers will be developed for dissemination to other interested parties and the general public.

Pre-workshop Activities

The organizing team established a Microsoft Office Sharepoint website as a repository for reference materials and communications with the participants. This included: a two-page document describing the workshop, pre-workshop presentations, mind mapping instructions, the consolidated mind map, participant provided background literature, workshop agendas, participant packets, and more.

Mind-mapping Exercise

The workshop organizing team initiated the mind-mapping exercise to provide information for selecting breakout session focal areas. The exercise also allowed participants to engage in the problem formulation exercise before the workshop.

Concept mapping[5] , also referred to as "mind-mapping" or knowledge mapping, was developed to assist in problem formulation and is used in both research and pedagogy. Mind-mapping is part of the idea of "knowledge cartography", which is "the art, craft, science, design and engineering of different genres of map to describe intellectual landscapes."[6]. Mind-mapping is a visually structured way of organizing how an individual conceptualizes an issue. There are various ways of describing and implementing mind-mapping. One useful set of essential characteristics identified by mindmapping.com includes:

1. The main idea, subject or focus is crystallized in a central image.
2. The main themes radiate from the central image as 'branches'.
3. The branches comprise a key image or key word drawn or printed on its associated line.
4. Topics of lesser importance are represented as 'twigs' of the relevant branch.
5. The branches form a connected nodal structure.

Mind maps can be constructed in many different visual formats, ranging from basic line drawings, to computer drawn diagrams to very artistic representations (as in Figure 3). We instructed participants to choose the style with which they felt most comfortable in producing their mind map.

[5] Safayeni F, Derbentseva N, Cañas AJ. 2005. A Theoretical Note on Concept Maps and the Need for Cyclic Concept Maps. Journal of Research in Science Teaching, 42(7), 741-766.
[6] Okada A, Buckingham-Shum S, Sherborne T (eds.). 2008. Knowledge Cartography: Software tools and mapping techniques. Advanced Information and Knowledge Processing, 1. London, UK: Springer.

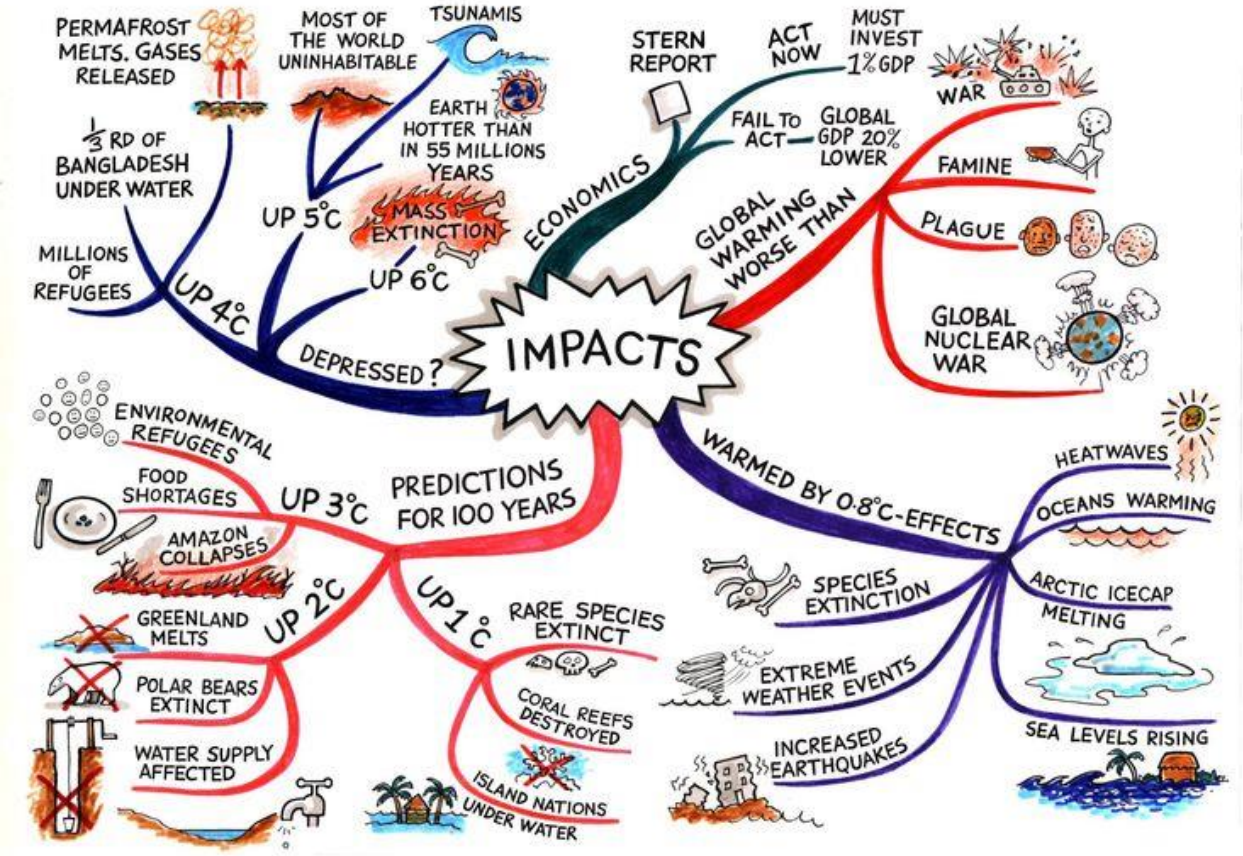


Figure 3. Example of a Mind Map for Climate Change Impacts
(Jane Genovese, http://www.mindmapart.com/climate-impacts-mind-map-jane-genovese/)

We provided participants two opportunities to attend a webinar to walk them through the "mind mapping" process [Appendix A]. We also provided a number of links to references on mind-mapping, including:

- "How to Mind Map in Three Small Steps" (Matt Tanguay), available at http://www.lifehack.org/articles/work/how-to-mind-map-in-three-small-steps.html
- Mind Mapping: How to Create a Mind Map in 4 Steps, available at https://www.youtube.com/watch?v=3iFH717xb90
- "How to mind map" tutorial, available at https://imindmap.com/how-to-mind-map/

Of the 44[7] workshop participants asked to contribute a mind map, 75% (33) completed the exercise in time for us to include their mind map in developing the consolidated "master mind map."

Mind-map Consolidation Process

[7] Between the mind-mapping exercise and the workshop, two invited participants cancelled their participation.

The organizing team consolidated the 33 mind maps into one single mind map using a seven-step process:

(1) We assigned each map a number and labeled it with the creator's name for contextual purposes. We recorded each map creator's name and corresponding number in a spreadsheet for reference. As shown in Figure 4, all 33 numbered and labelled maps were laid out on a table in six rows of five and one row of three. The "free form" or non-traditional "node-to-branch" mind maps were grouped together into the first rows, and the traditional node-to-branch maps in the subsequent rows (see examples of each, figure 5.a and 5.b).

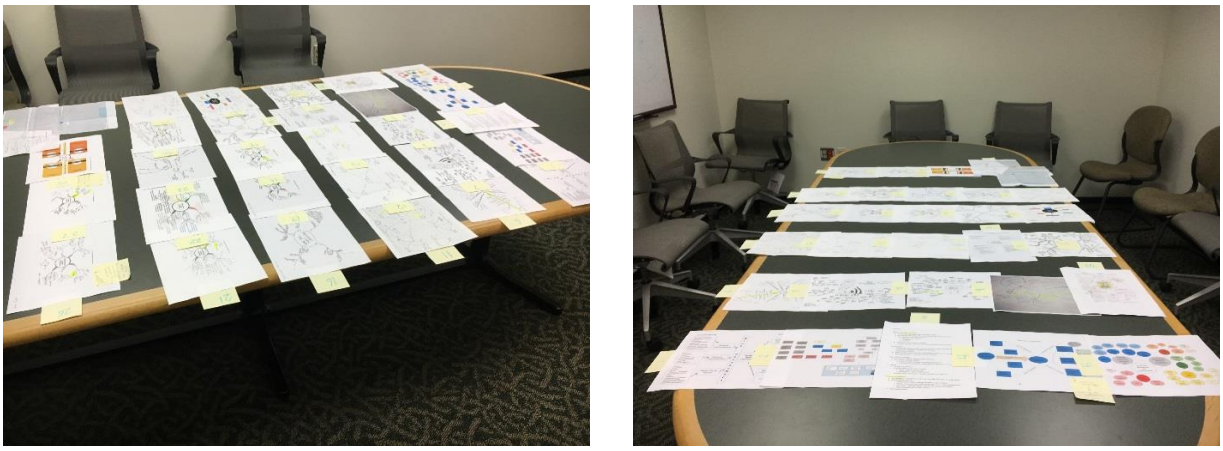


Figure 4. Numbered and labeled mind maps.

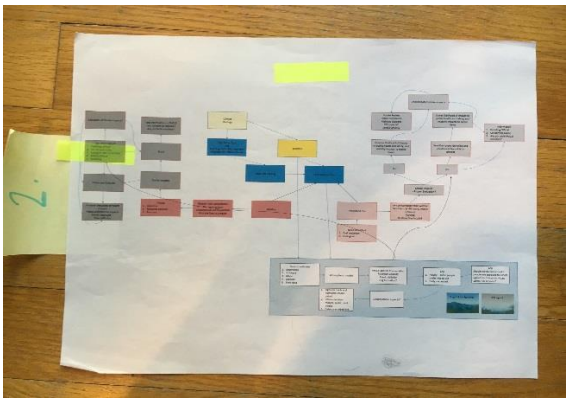


Figure 5.a Example of "free form" or non-traditional mind map structure.

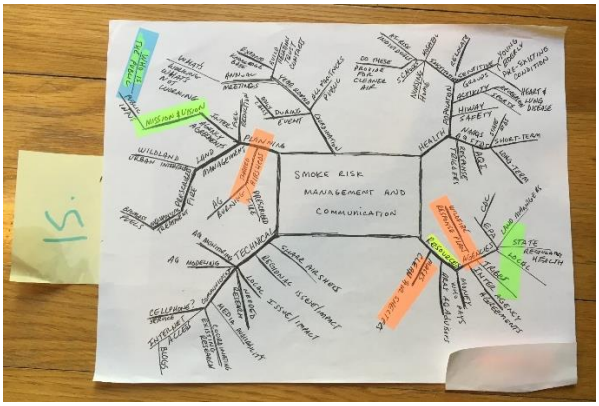


Figure 5.b Example of traditional node-to-branch mind map structure.

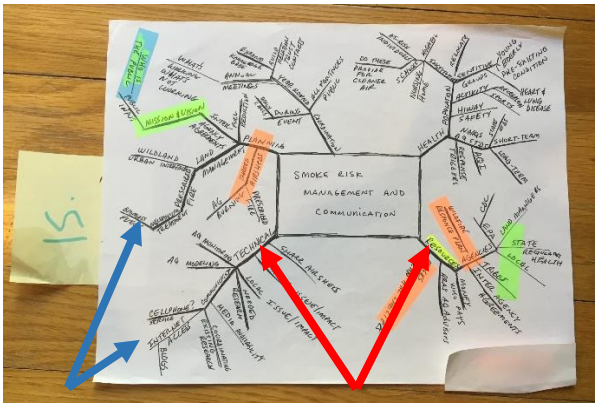


Figure 5.c Red arrows indicate “primary nodes,” blue arrows indicate “branches.”

(2) The organizing team consolidator (K. Schulte) examined each individual map and made a list of what was articulated at the center as the main concept or problem.

(3) Starting with one row of five maps, the consolidator developed a list of primary nodes (see Figure 5.c). Rather than listing out all of the primary nodes in each of the 33 maps, the consolidator reviewed a row of five maps at a time and made tally marks next to primary node listings that were either articulated similarly or repeated verbatim in each subsequent map reviewed. If a primary node on a particular map was expressed uniquely it was added to the primary node list. As the consolidator reviewed the primary nodes of each individual mind map during this step, she made note of primary nodes that could potentially be categorized as secondary nodes or branches (see Figure 5.c) by including (N^2) next to it. The consolidator simultaneously made notes of particularly unique or unconventional ideas incorporated into the mind maps.

(4) Upon reviewing all primary nodes in each of the mind maps, the consolidator repeated the process for all secondary nodes, tertiary, etc.

(5) Following the detailed review and notation of both the primary and secondary nodes contained within the individual mind maps, the consolidator completed a preliminary master mind map featuring the most frequently cited nodes or ideas as the five main focal areas branching from the center of the map. Subsequently, the consolidator wrote in each primary or secondary node listed from step 2 and 3 as a secondary node on this rendition of the master mind map. To ensure that each idea or node was addressed and properly placed within the master mind map, the consolidator carefully reviewed the lists generated in steps 2 and 3 and placed check marks next to each node once it had been incorporated. Certain secondary and tertiary nodes appear under multiple primary node focal areas.

(6) Once completed, the consolidator digitized the master mind map using Adobe Illustrator software. We made the master mind map available to workshop participants one month prior to the date of the workshop via the Microsoft SharePoint website. Participants were encouraged to

review the map and, if they were a designated presenter, to focus on certain elements of the master mind map during their presentation.

(7) On the day of the workshop, two large poster prints of the master mind map were hung at either side of the auditorium where the majority of the workshop activities were to take place. Pens and sticky-notes were provided beside each poster and participants were encouraged both before and during the workshop to make any edits or additions to the nodes on the master mind map. By the end of the workshop the participants had contributed a significant number of edits and additions. The consolidator then re-incorporated the new nodes and edits into what will be referred to as the final rendition of the master mind map (see figure 6.a & 6.b)

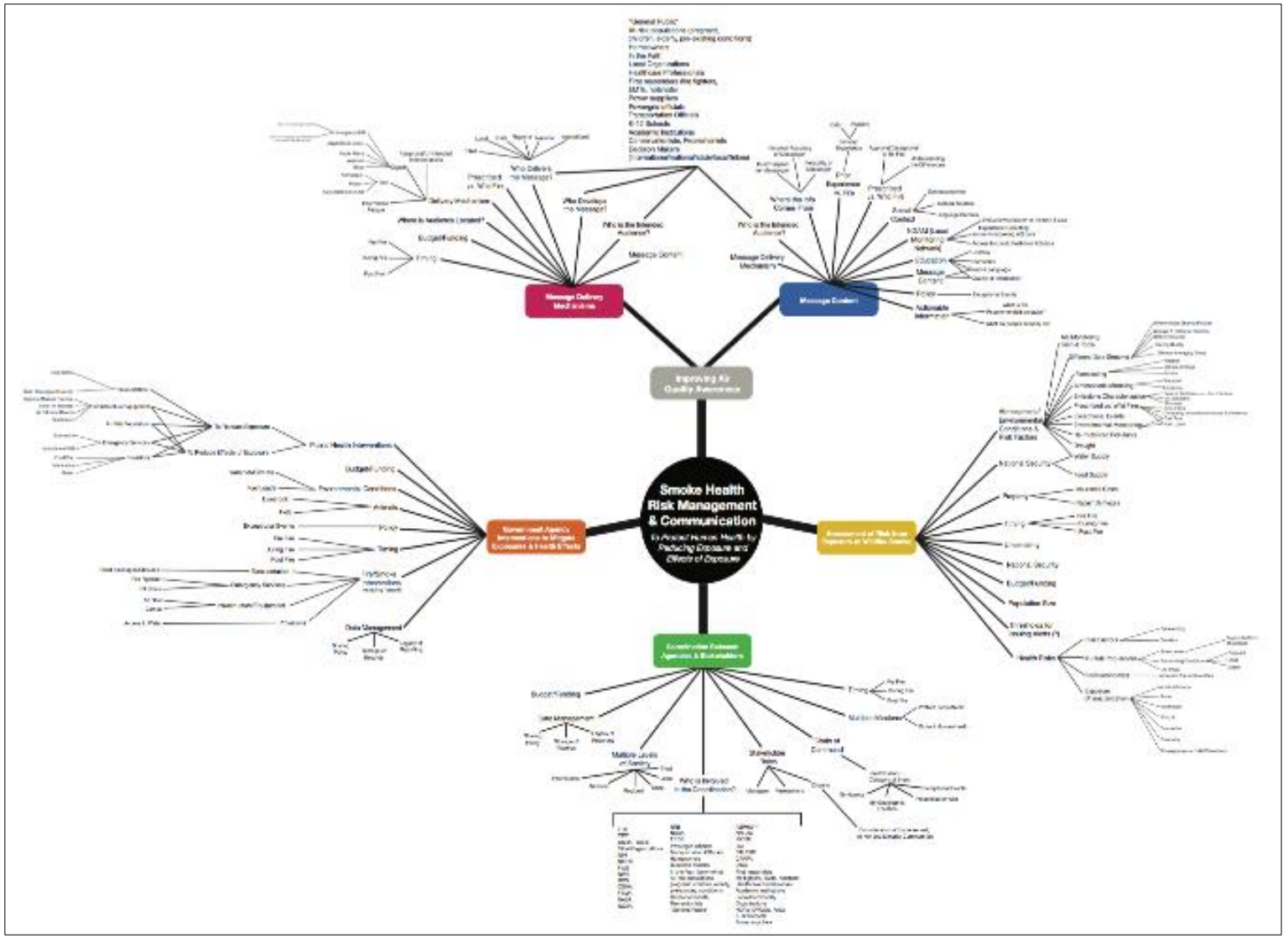


Figure 6.a Digitization of hand-drawn Master Mind Map, shared with participants one month prior to workshop (paneled version of mind map can be found in Appendix B)

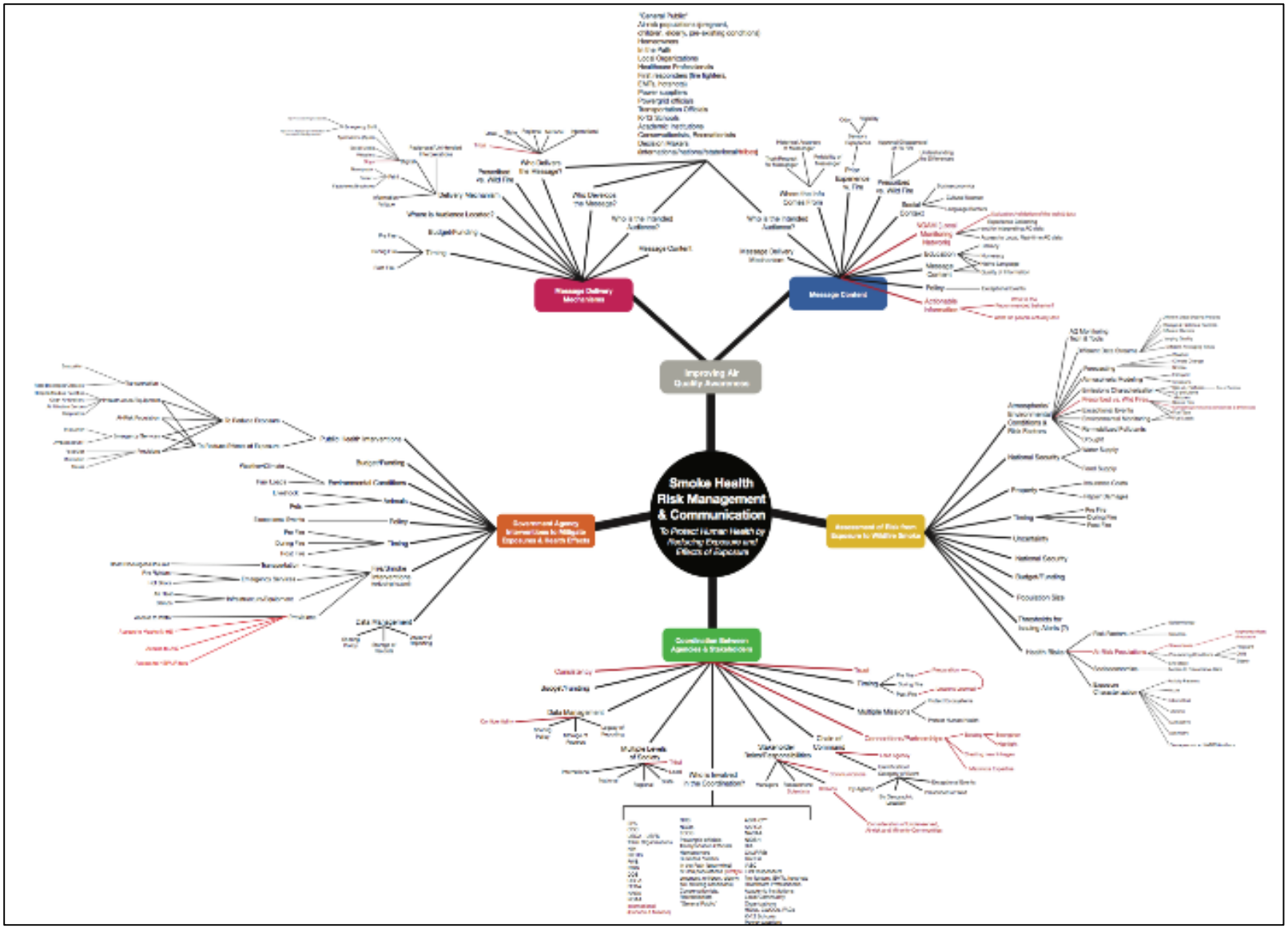


Figure 6.b Final rendition of Master Mind Map, including incorporation of edits and additions made during the workshop (a paneled version of mind map organized by nodes can be found in Appendix B)

Workshop Day 1

Overview

The first day of workshop activities included 10 minute contextual presentations on community engagement, multi-state/regional/federal engagement, and research perspectives, which provided a context for the first set of breakout group discussions. The participants then formed five breakout groups around the focal areas identified through the mind-mapping exercise. The organizing team tasked these breakout groups with developing comprehensive problem statements which addressed the importance of the topic, the current state of the topic, the desired state of the topic, and what is needed to bridge the gap between current and desired states. Finally, the day ended with one minute "advertisements" highlighting the following posters and demos in the final session designed for researchers to discuss their current work with wildfire smoke research.

Setting the Stage: Kris Ray, Confederated Tribes of the Colville Reservation Nespelem, WA

8:15 am

Mr. Ray presented experiences of the Confederated Tribes during the "monster fires" that affected the area in and around the Colville Reservation in 2015. A two-year drought in the area coupled with very high temperatures, which created a perfect environment for wildfires. These "monster fires" persisted over a two-month period from June to August, 2015, burned 523,000 acres, had an economic cost of over $66 million, and killed three firefighters in north central Washington state. They also resulted in the evacuations of nine different communities, and the destruction of hundreds of homes, businesses, and buildings. During these fires, power outages were widespread, and the fires damaged lines of communication, such as local radio stations, so that traditional means for communicating risks from smoke were not available. Communities relied on cell phones for communication, if reception was available. Communities also used social media, such as Facebook, to communicate. There were not enough fire fighters, and as a result, smoke inundated communities. Air quality was poor in many communities impacted by the fires, and $PM_{2.5}$ concentrations exceeded 500 $\mu g/m^3$ in several locations for several days. Indoor $PM_{2.5}$ concentrations could also be extremely high. Mr. Ray provided numerous images of the devastating impacts of the fire on the Colville Reservation, including the one shown below in Figure 7. Many community members were farmers and ranchers, and an important issue during the event was where to put livestock during an evacuation.

Figure 7. Colville Reservation inundated by smoke during 2015 wildfire episodes (Source, Presentation by Kris Ray)

Welcome and Introduction

Bryan Hubbell, U.S. EPA Office of Air Quality Planning and Standards

Dr. Hubbell welcomed participants and provided background context on the structure of the workshop and the goals of interdisciplinary, multi-stakeholder problem formulation. Understanding and addressing the issues associated with wildfire risk communication and management is fundamentally an interdisciplinary task. Because communication occurs at many different social levels, for example federal provision of air quality data and community outreach programs, it is essential to understand the social and technical dimensions of delivering effective information to different portions of society.

Bringing together diverse disciplinary and stakeholder perspectives during the problem formulation stage will increase the potential usefulness of the results of interdisciplinary research. The goal of problem formulation is to lay out research questions or hypotheses in simple, clear, concise terms that are understood by all of the disciplines and stakeholders involved.

Key elements of this workshop are the development of problem statements and research questions. Problem statements should concisely describe why an issue is important, what is known about the issue (e.g. what is the current state?), where do we want to be on the issue

(e.g. what is the desired state?), and what are the gaps in knowledge, technology, or practice that are preventing us from moving from the current state to the desired state.

Having a clear problem statement will then facilitate the development of research questions or possible directions for solutions. In developing the research questions and potential solution directions, it is important to keep in mind and describe the types of expertise needed, the potential level of resources (funds, people, equipment) required, the intensity of data collection and likely time frame for the research.

Ana Rappold, U.S. EPA National Health and Environmental Effects Laboratory
Dr. Rappold provided background information and the motivation for the workshop from a public health perspective. Research on the health effects of exposures to wildfire smoke has increased in recent years; over 60 articles on the health impacts of smoke were identified in two recent review[8]. Health effects associated with smoke exposure include: all-cause mortality, asthma and COPD exacerbations, bronchitis and pneumonia, childhood respiratory disease, cardiovascular outcomes, adverse birth outcomes, anxiety, and symptoms such as eye irritation, sore throat, wheezing, and coughing. Populations susceptible to smoke exposures include: fetuses, children, older populations, populations with pre-existing respiratory disease, populations with pre-existing cardiovascular disease, and populations with lower socio-economic status. Additional populations suspected to be at greater risk include those with chronic inflammatory diseases (e.g., diabetes, obesity), and specific genetic polymorphisms (e.g. GSTM1) that mediate physiologic response to air pollution. Recent work in Canada has focused on outreach and education, and evaluation of actions to reduce smoke exposures including using respirators when outdoors and designating clean shelters where individuals can go to avoid smoke exposures.

Fires are a significant source of $PM_{2.5}$ emissions in several regions of the U.S. Wild and prescribed fires contribute 40% of directly emitted PM2.5 based on the 2011 National Emission inventory, however the impacts are not uniform across all geographic areas. As shown in Figure 8, in Southeast and Northwest regions, fires can contribute between 1.5 and 4.58 $\mu g/m^3$ to annual mean $PM_{2.5}$ concentrations (12.5-38% of the annual NAAQS 12 $\mu g/m3$)[9].

[8] Liu, J. C., Pereira, G., Uhl, S. A., Bravo, M. A., & Bell, M. L. (2015). A systematic review of the physical health impacts from non-occupational exposure to wildfire smoke. *Environmental research*, *136*, 120-132.
Reid, C. E., Brauer, M., Johnston, F. H., Jerrett, M., Balmes, J. R., & Elliott, C. T. (2016). Critical review of health impacts of wildfire smoke exposure. Environ Health Perspect, 124(9), 1334-43.
[9] Rappold, A.G., Reyes, J., Pouliot, G., Cascio, W.E., Diaz-Sanchez D., Community vulnerability to health impacts of wildland fire smoke exposure. In review.

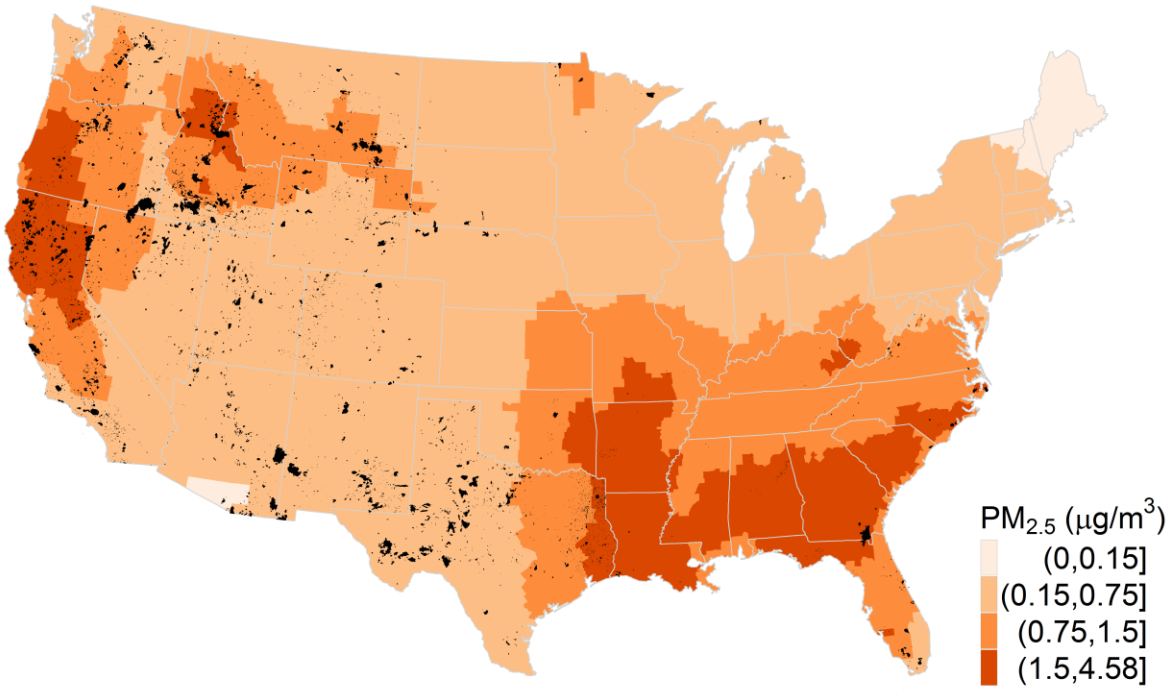


Figure 8. CMAQ estimated impact of wildland fires for continental US on Annual Average PM2.5 concentrations for period 2008 through 2012 together with GeoMAC perimeters of area burned by large fires (http://rmgsc.cr.usgs.gov/outgoing/GeoMAC/historic_fire_data/).

Additionally, Dr. Rappold noted that on days where a smoke plume is present, the likelihood of experiencing a code orange (unhealthy for sensitive groups), red (unhealthy), or purple (very unhealthy) AQI reading is over 4 times higher for ozone, and almost 3 times higher for $PM_{2.5}$ when compared with AQI readings when no smoke plumes are present[10].

EPA plays an important role in informing the public and air quality officials about air quality during smoke events, and alongside other federal and state agencies, provides guidance on what to do during smoke events. One method that EPA uses to communicate about air quality is the AirNow website, which provides current and forecasted values of the AQI. However, little is known on why and who access the AirNow data and whether the information reaches all segments of population. During wildfires in Washington in 2015, AirNow sessions peaked at over 40,000 daily, compared to a normal rate of only a few hundred. During a large fire in Florida in 2015, AirNow sessions peaked at around 350 per day. This suggests that better communication about available tools in areas of the country that have not had as much experience with large wildfire events may improve awareness and use of these tools.

[10] Larsen Alexandra, Brian Reich, Mark Ruminski and Ana G. Rappold, *Impacts of Wildfire Smoke Plumes on Regional Air Quality*, The proceedings of 5th Fife Behavior and Fuels Conference, 2016.

Dr. Rappold then emphasized that a goal of the workshop is to bring together a diverse set of experts to share insights on 1) the nature of the public health problem associated with smoke exposures that accurately reflects community and individual-level attributes, and 2) what types of information and actions related to risk communication and management might warrant further scientific evaluation and research. The overarching goals of the workshop are to provide a more comprehensive understanding of the problem of public exposure to smoke from wildland fires, and to frame the problem in a manner that highlights avenues for developing solutions via applications of research and advancing technologies.

Contextual Presentations:

Community Engagement
8:55 am

Christine Olsen, Oregon State University, Corvallis, OR
Dr. Olsen provided her perspectives on key elements of risk communication: perceptions, messaging, and relationships. People in areas with experience with wildfires have strong perceptions that it is likely that they will experience a wildfire near their home; this generally results in an overestimate of risk. The public acceptance of smoke exposure varies by the source of the smoke, e.g. wildfire, prescribed burn, agricultural fire, managed wildland fire, waste piles, or private burning. Factors that influence acceptance of smoke exposures include: smoke health risks, prescribed fire benefits, confidence in agencies, being in a rural area, age, other smoke risks (not health), education, and having experienced smoke impacts, both health and non-health. Factors that did not influence acceptance of smoke exposures include how many times a person was provided communication about the smoke, and level of knowledge about smoke.

Perceptions of risk are the product of the likeliness of an event times the severity of the event. Perceptions are influenced by negative impact on: family and personal health, scenery impacts, reduced tourism, personal recreational and travel opportunities, and impacts on work and activities.

Relationships with agencies that make decisions regarding management of smoke events are important. Individuals need to trust that agencies will make good smoke management decisions. Agencies with whom individuals have a moderate degree of trust include state departments of forestry, local Forest Service staff, private consultants, county air quality districts, state EPA air resources board, private landowners, U.S. EPA, and US agencies in DC. Trust in state agencies tends to be greater than trust in federal agencies.

Good messaging requires careful attention to content. Important content includes information on health risks and protective behaviors. It is important to provide sources and objective information, as well as advance warnings. Messages can be effectively delivered through local connections/faces. Many people experience risk communications about smoke through TV/radio

public service announcements, newspapers, family and friends, billboards/road signs, visitors' centers and interpretive signs. Based on a survey on usefulness of communications, educational workshops were identified by only 11% of respondents. Conversations with agency staff (26%), state air quality call line (22%), forest agency web pages (22%) and government public meetings (17%) were the most frequently identified sources of information.

Challenges to effective communication about smoke include inconsistent messages and difference in internal agency priorities. Addressing these challenges requires managing consistently across boundaries, prioritizing to reach audiences, and fostering relationships with the public (people want to believe an agency cares about them).

Deyonne Sandoval, New Mexico Department of Health, Santa Fe, NM
On behalf of a multi-entity work group, Ms Sandoval provided perspective on how a team, comprised of professionals in diverse sectors of air quality and public health, designed a wildfire health risk communication system for New Mexico taking into account factors such as regional culture, health behavior, terrain, and aspects of the local environment. The methods to create this system utilized community health theories, models and frameworks, inclusive of the Diffusion of Innovation theory, social marketing models, a hybrid of risk communication models, the public health model, and applied sciences. The resulting system includes 1) an empowering health tool, called 5-3-1, allowing people to quickly make decisions that could minimize their risk of smoke and particle inhalation, 2) a classification of risk communication actions, and 3) determination of cost-effective modes to deploy messages to indicated populations.

Toward empowering citizens, especially in the absence of air quality monitors, the New Mexico team created the 5-3-1 tool, which offers people a way of judging poor air quality during smoke events by using visibility and taking advantage of the geological variations in the New Mexico landscape. The approach is simple and requires few resources. Citizens, public health officials and community leaders can access a website, https://nmtracking.org, to learn how to do it, download the steps and access a toolkit to make decisions about outdoor activities such as physical activity and sports.

To strategically deliver health messages, alerts, and promote the use of 5-3-1, the New Mexico system classifies risk communication actions based on the level of risk and the level of concern. These classifications represent opportunities for actions that empower, prepare, and educate populations. For example, before the fire season, messages are focused on preparedness, because at that point, there is a low-harm likelihood. The seasons for wildfires and prescribed burns tend to coincide with the season for outdoor activities such as baseball, softball, golf, festivals, fishing, and outdoor work for occupations such as farming, ranching, and construction. Since this presents a potential high-risk scenario, active health communication is delivered in ways to reach selected audiences. Other categories focus on risk-perception management.

In each classification level, messages are deployed based on what is known about the population of concern, the location and concern level. It has been effective to use different forms of low-cost message dissemination formats when the approach is based on community needs and

delivered based on the types of media or communication outlets people in the community can realistically and quickly access. The flexible approach allows for focused and tailored message delivery to communities most impacted smoke while reducing the perpetuation of fear in areas not affected. Recent data collected in New Mexico show that the primary means for finding information about smoke is shifting. In 2015, the primary drivers for reaching the New Mexico smoke website were referrals and search engines. In 2016 these drivers were referrals, including digital media sources, and social media. This has implications for the use of these platforms for timely public health notifications.

The lessons learned from New Mexico's approach stress the magnitude of coupling the knowledge and skillsets of the applied, natural and social sciences. This method resulted in a system and products specialized for this culture and the terrain.

Marissa Hauptman, New England Pediatric Environmental Health Specialty Unit/Harvard, Boston, MA

Dr. Hauptman, a pediatrician and faculty at the Region 1 New England Pediatric Environmental Health Specialty Unit (PEHSU) presented perspectives on risk communication. The PEHSUs are a network of experts with offices in EPA regions, who work to improve the environmental health of children and women of reproductive age by providing educational and consultative services to clinicians and health professionals and communities. Their work bridges the disciplines of public health, health, and community groups by: supporting the need for specific clinical information on environmental toxins; partnering with local, regional and national health departments and governmental agencies; providing health provider education and training opportunities; participating in clinical assessments and referrals as needed; engaging in public outreach activities; giving advice to residents and community leaders; and facilitating early response to public health issues.

Dr. Hauptman integrates risk communication strategies into her daily work in environmental medicine. An example of wildfire risk communication strategies could include establishing multiagency, multidisciplinary partnerships to develop "Message Maps." For the Message Maps, it is important to specify a target audience. For children, the Message Maps include three key messages: "What is the issue?"; "What does this mean for my child's health?"; and, "What can I do to protect the health of my child?".

Specific strategies for building trust and communicating effectively with the public include involving trusted community stakeholders early in the process, for example by creating a community advisory board. Being transparent in addressing any uncertainties in the science is also important. Finally, biomonitoring can be challenging when there are not meaningful and actionable pediatric and adult reference levels. The PEHSUs have developed fact sheets specifically about children and wildfires and are available at www.pehsu.net.

Louie Rivers III, North Carolina State University, Raleigh, NC

Dr. Rivers presented his perspective on engaging with communities about environmental risks. There are a number of developmental stages in risk management/communication[11] identified in the literature, including:

- All we have to do is get the numbers right
- All we have to do is tell them the numbers
- All we have to do is explain what we mean by the numbers
- All we have to do is show them that they've accepted similar risks
- All we have to do is show them that it's a good deal for them
- All we have to do is treat them nice
- All we have to do is make them partners
- All of the above

Public inclusion is an important component of risk governance, including communication and management, but the other elements of pre-assessment, risk appraisal, risk characterization, and risk evaluation are also important. Agencies are getting better at including the public in examining risk. Social trust is necessary for effective risk governance; social trust is the willingness to rely on those who have the responsibility for making decisions and taking actions related to the management of technology, the environment, medicine, or other realms of public health and safety, for example, governments, schools, and doctors[12].

Social trust is supported by shared similar values, use of similar rhetoric or language (e.g. do I sound like you), similarity of appearance (e.g. do I look like you), perceived shared life experiences, social connections, and history[10]. In Dr. River's experience, social trust has declined, based on recent experiences with the Keystone pipeline, Flint/Detroit, and the Dakota Access pipeline.

Community engagement, especially with minority and underserved communities, is required to build trust. These engagements need to: be tailored to each community, recognize that communities are not homogenous entities, be respectful, treat the community as equals, be approached with honesty, humility and commitment, seen as a long term investment, allow real access to power (the ability to make and carry out decisions), develop symmetrical trust (agencies must trust communities as much as communities trust agencies), and see communities as partners in addressing a challenge.

This will require developing relationships with multiple community leaders, bringing in diverse agency representatives, involving people directly from the community, and understanding the community history with government agencies, including those not directly involved in the issue,

---

[11] Fischhoff, Baruch. "Risk perception and communication unplugged: twenty years of process." Risk analysis 15.2 (1995): 137-145.

[12] Siegrist, Michael, and George Cvetkovich. "Perception of hazards: The role of social trust and knowledge." Risk analysis 20.5 (2000): 713-720.

e.g. interactions with law enforcement may influence how communities see environmental agencies.

Question & Answer

To what end do we pursue community engagement? What do we actually want people to do, and do they need to be engaged for that to happen?

> The goal is to change behavior to avoid serious health effects, like going to the hospital – this requires people to understand their own personal risk. The community at some level needs to be involved in how we formulate problems so that we really do address individual community needs. Building relationships between agencies and communities can help to reduce risk to the public by building ownership and understanding to allow for better management. Better communication between clinicians and the public can also prevent the need for unnecessary health care.

Public acceptance was discussed related to prescribed vs wildfire, is that different in attainment vs nonattainment areas? If it is not a chronic problem?

> There is not a big difference between nonattainment and attainment areas because the nonattainment label is not attributed to land management. When the public awareness level about the risk posed by unmanaged fires is higher, there is a greater level of acceptance of intrusion and management.

Are there ways to engage groups that do not belittle the trust issues with other parts of the government?

> If people can put a face to your agency it helps to build trust. For example, Durham has a wetlands center, people associate that center with the city, and trust the information they get from the center.

Contextual Presentations:

Multi-State/Regional/Federal Engagement

10:05 am

Pete Lahm, US Forest Service, Washington, DC

Mr. Lahm provided his perspectives on the federal Wildland Fire Air Quality Response Program. The purpose of the program is to operationally address smoke from wildfires to protect public health and safety, public and fire personnel transportation safety, and reduce fire personnel smoke exposures. The program has four components: monitoring, modeling, messaging, and coordination. The monitoring program includes 25 deployable emergency $PM_{2.5}$ monitors and a cadre of 30 Air Resource Advisors (ARAs) and 23 trainees. These ARAs are dispatched primarily to

wildfires as part of the incident management team. The program makes use of custom designed operational tools for smoke forecasting. The USFS Pacific Northwest Research Station–AirFire Team uses BlueSky $PM_{2.5}$, monitoring data analysis tools, complexity tools, and partnerships with NOAA to obtain 1km weather grids.

The program prepares a number of communication products, including:

- Daily one-page area smoke outlooks (AQI $PM_{2.5}$ thresholds & advisories) and blog posts
- Daily in depth documentation collected and available at www.wildlandfiresmoke.net
- Public and cooperator on-site meetings
- Coordinated messages (through calls) developed with state/local/tribal air quality and health agencies, the National Weather Service, and schools

The program has trained over 60 ARAs, with an initial review of the program in April 2015, and a field assessment in CA, WA, and OR in 2015. The program provides continuing education and refresher webinars, and a guide book is being developed.

At the incident level, the ARA is most effective at utilizing on-scene knowledge of fire activity and behavior, fuels, consumption, weather, and dispersion; and recognizing local needs and validation, working directly with the public; however, challenges remain on how to combine information across incidents to create a larger scale smoke picture; and adjusting local smoke forecasts to account for the impacts of other fires. At the multi-fire, state, and regional level, challenges include reliance on remote information (fuels, consumption, fire activity, dispersion, impacts), use of simplified broad-scale forecasting, and the need to focus on public smoke impacts. Finally, the growing influence of large scale national and international fires on regional and local air quality in the U.S. needs to be understood and addressed.

Mike McGown, US Environmental Protection Agency Region 10, Boise, ID
Mr. McGown provided his perspectives on interagency coordination before, during, and after smoke events. He works closely with tribes in Region 10 and in the state of Idaho. The goal of interagency coordination is to foster communication, coordination, and collaboration on technical, regulatory, and policy matters. This requires developing a shared mission and vision for both prescribed and wildfires. The mission and vision statement for prescribed and wildfires came from interdisciplinary and inter-agency coordination between federal and state land management agencies, and state and tribal air regulatory agencies. There is an Executive Smoke Team which is comprised of agency heads for EPA, state air agencies, tribes, federal and state land managers and other key partners.

EPA Region 10 convenes an annual “Smoke in the Northwest” meeting of federal, tribal, state, and local agencies, and private partners to “share information about smoke management including regional and national policies, new tools, available resources, forecasts, and management plans. Participants work together to manage burning and smoke to protect the public and the environment.” They also maintain a collaborative Microsoft SharePoint site for collaborative information sharing and project follow-up.

Region 10 works to facilitate wildfire air quality responses and coordinate prescribed fire and agricultural burn programs within the region, as well as providing air quality support to states and tribes. In recent years they have broadened participation and the scope of their outreach resources, including working with land managers and participating in the Forest Service's Air Resource Advisor Program and serving as instructors at RX410 Smoke Management Training for burn bosses. Region 10 staff have attended prescribed fire and other fire related trainings.

Scott Damon, Centers for Disease Control and Prevention - National Center for Environmental Health, Atlanta, GA
Mr. Damon provided his perspectives on risk communication, focusing on three key questions for the risk communicator: "What do I already know?", "What do people want to know?", and "What do I need to find out?". Further refining the first question, he asked what leads you, in preparing a communication response, to focus on certain things? The answer includes the presence of high-risk groups (e.g., asthma, CVD, etc.), frequency of fires in the area where you will be communicating risk, and logistics—budget, available resources, available channels, and limited time to formulate a response. For the second question, the answers include: "What can we expect?", "Is my family safe?", "How can I protect us?", "Can you fix this?", and "Who is in charge?" and consistent messaging between responding agencies is important. The answer to the third question requires engaging with communities at risk from wildfire smoke. Understanding community knowledge, attitudes, and practices requires understanding the community's recent experiences with wildfires and smoke, how the community is segmented by demographics and other factors, and the community's media habits, i.e., how to deliver messages. Research needs to support improved risk communication to communities include identifying useful models of communication, accessing existing formative information (e.g. using existing audience data, determining regions, audiences, etc. for whom audience profiles are already "in hand") using methods for rapidly assessing audiences, and identifying ways to respond with limited resources and/or time.

The Centers for Disease Control and Prevention (CDC) has an online Gateway to Health Communication & Social Marketing Practice which provides a process for planning and conducting crisis and emergency risk communication, along with information to help emergency response teams, available at
http://www.cdc.gov/healthcommunication/risks/index.html

Greg Vlasek, California Office of Emergency Response - Air Resources Board, Sacramento, CA
Mr. Vlasek provided his perspectives on wildfire air monitoring response coordination. California's basic air quality response model includes three elements: data collection, turning data into messages, and delivering messages to audiences. The California Air Response Planning Alliance has a Wildfire Smoke Response Coordination guide that compiles best practices and approaches for California. The guide describes the duties and roles of different agencies, and provides a concise (10 pages) set of information including examples, templates, and contact information, as well as recommended health protective actions. The guide is available at
https://www.arb.ca.gov/carpa/cawildfiresmokeresponsecoordinationaug14.pdf

The California Air Resources Board engages in a number of data sharing and coordination activities including: daily intelligence briefings by email and phone; a daily smoke call which provides a 12 to 96 hour outlook; a daily monitoring call which included personnel from affected districts, air resource advisors, and the air resources board; and addresses staffing needs and coordination of activities over a 12 to 96 hour period; and a weekly call between CARB and U.S. EPA.

Raw monitoring data is quality assured using automated procedures to ensure highest possible quality data is used in messages, given the urgency of posting hourly data updates. Data is provided through the AirNow wildfire webpage which provides a dynamic map with information on fire locations, smoke plumes, $PM_{2.5}$ AQI, and incident information (see Figure 9).

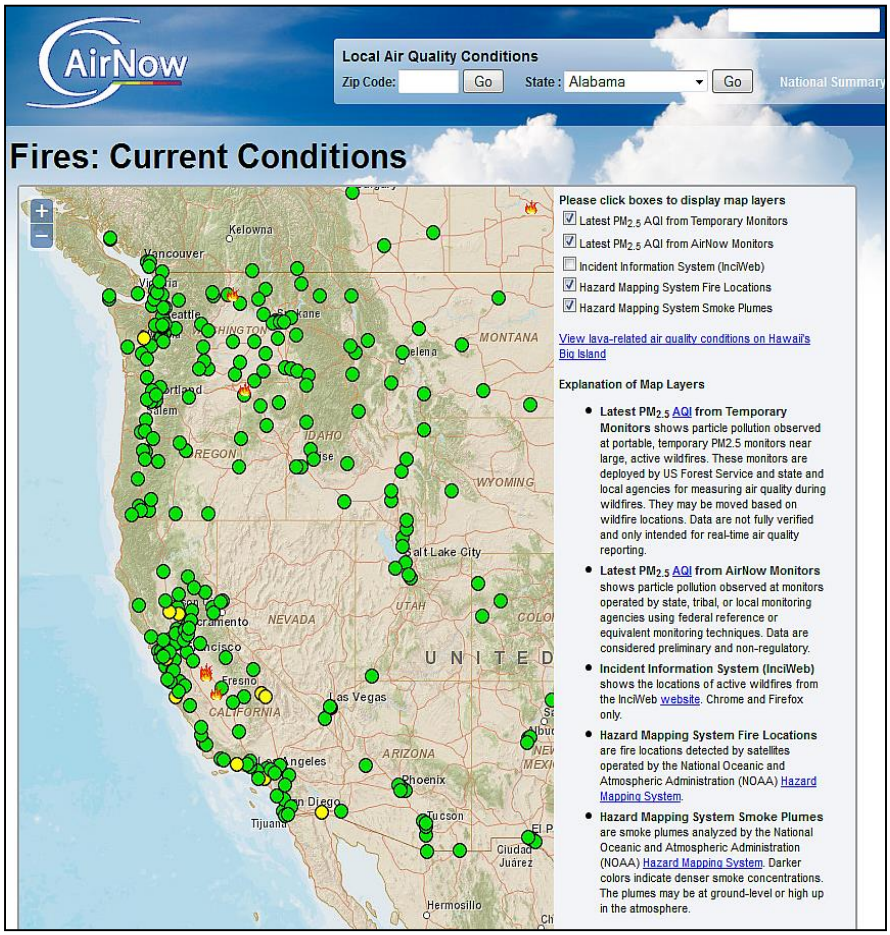


Figure 9. Example AirNow Map of Fires in the Western U.S.

In addition, the Air Resources Board reports use the US Forest Service's AirFire webpage as a visualization tool, which includes maps of fire locations and graphs of daily $PM_{2.5}$ concentrations from portable monitors near wildland fires. The website also provides twice daily modeled plumes for major fires which provides estimated $PM_{2.5}$ values for a 72-hour forecast period.

California uses several public messaging tools to inform the public about current and projected smoke impacts. These include the California Smoke Information blog, smoke impact summaries, and Twitter posts (which draw from the blog). Several independent and private organizations, including *yubanet.com* and *KPCC radio FireTracker,* maintain seasonal wildfire status web pages, drawing on data from the Air Resources Board, US Forest Service, California Air Response Planning Alliance, AirNow, and other sources**.**

Mary Anderson, Idaho Department of Environmental Quality, Boise, ID
Ms. Anderson provided her perspective on how Idaho has responded to wildfires. Idaho has a small air quality division. There are 6 regional offices which perform smoke forecasting, and respond to complaints and questions. The program office in Boise provides overall guidance to the regional offices. The division works closely with tribes in Idaho and communities within the state. Prior to 2012, the Department of Environmental Quality (DEQ) did not provide much in the way of emergency response, instead just provided smoke forecasts. In 2007, the public did not ask for more information. Idaho experienced monster fires in 2012, and was affected by smoke from fires in Oregon and Washington. In this situation, the state agencies were playing catch-up, including working on weekends. However, agencies did not have a shared sense of mission. In some cases, no contacts were provided to cover weekend events, which created problems for managing the smoke impacts. Poor coordination with the division of health resulted in a lack of clarity on whether facemasks[13] should be deployed.

Since 2012 and looking at what has worked in other states, progress has been made based on a prepared response and coordination between agencies. Idaho has worked closely with Washington and Oregon to create communication protocols, including a blog to communicate smoke risk. Recognition that normal day-to-day business is not set-up for wildfire response has led to a regularly staffed response group that works between agencies and can help prepare for an emergency like wildfires. This group arranges daily calls when needed, and supports rapid decision-making.

An important remaining issue is that the public wants to know the difference between an overall "moderate" AQI level which reflects daily $PM_{2.5}$, and a situation where air quality is bad in morning, good in afternoon, and bad at night – how do we design a system to provide this information? Also, a more proactive response is desired, e.g. information on using facemasks and adding emergency monitors, recognizing that even though they aren't the best option or provide lower quality data respectively, that they may be useful.

Question & Answer

How do the California daily calls fit into the incident command at the fire?

> Forest service air resource advisors are assets and are plugged in. They reach out to the fire camp with calls. Partnership with the forest service is truly critical.

[13] An example of a facemask that protects from the particles in smoke would be an N-95 respirator.

We heard about coordination in the northwest, what is it like elsewhere in the country?

> Highly dependent on the time. Some other states utilize similar coordination calls, but there is more focus on prescribed fires than wildfires. There are also phones calls put together by air resource advisors, but these are very situational, rather than routine planning.

How much difference does this coordination make for the public?

> Smaller towns do not have some types of media outlets; thus meetings are very important. In Idaho, schools wanted the DEQ to make the decision concerning school activities, but now are making those decisions themselves based on the DEQ forecasts.

How can we forecast better knowing that the public is making their own decisions about outdoor activities?

> For major cancellations of outdoor activities due to smoke hazards, communities will make decisions based on the information given. Letting people know when there is a clean air forecast in a regularly hazardous area is also valuable.

With regards to dust masks, if these aren't effective, what should I be doing?

> The public always has trouble determining the right thing to do. Talking to your health provider is not necessarily helpful either. Facemasks are not always necessarily worn properly.

Is there information about how to wear those properly?

> Wildfire Smoke Guide provides information related to this problem. Access to a HEPA filter is useful as well. This information is needed by small towns to send out to their citizens.

Contextual Presentations: Research Perspectives

11:10 am

Bruce Shindler, Oregon State University, Corvallis, OR

Dr. Shindler provided his perspectives on his experiences researching public interactions around wildfire mitigation, suppression, and risk. Context of smoke exposures is extremely important to consider. Wildfire management is composed of several related activities including suppression, mitigation (including tree thinning, prescribed fires, mowing and grazing, herbicides, and natural fire), public engagement (understanding and response), and post-fire restoration. In 2015 suppression activities were applied to 10 million acres at a cost of $2 billion – some research

suggesting this could quadruple in 10 years. Many agencies spend the most money on suppression activities – not mitigation or response or restoration.

Related to everything else in their lives, people have questions, fears, and uncertainty about the impacts of wildfires and smoke. Mistrust over past management practices is an issue. Public understanding and response requires communication between scientists, managers, and the public. This is occurring, but too often it is one-way communication. More effective fire and smoke management requires moving to two-way, back and forth communication between agencies and managers. An example is the film "The Era of Megafires: How do you want your fire? How do you want your smoke?" Social science helps to increase understanding of how stakeholders and partnerships are working together.

Rob Elleman, US Environmental Protection Agency Region 10, Seattle, WA
Dr. Elleman provided his perspectives as an EPA regional scientist working on smoke and air quality. Smoke risks have a clear spatial dimension, with total risk being determined by the intensity of the smoke exposure, which is inversely related to the distance from a fire, and the population exposed to the smoke, which grows with distance from a fire due to the dispersion of smoke over a broader spatial area. What this means is that at the highest levels of smoke intensity, there are very high hazards, but relatively fewer people are exposed to these hazards, while downwind, there are lower levels of smoke intensity, and lower hazards, but relatively more people are exposed. In addition, cities tend to be located some distance away from the fire. As a result, the public health impacts resulting from smoke from a fire may be larger further away from the fire, even though individual risk may be highest directly adjacent to a fire.

Populations nearest to fires are exposed to a wide range of air pollutants including $PM_{2.5}$, carbon monoxide, dust (PM_{10}), and many air toxics such as metals, asbestos, etc. EPA has less of a role directly near fires. Managing exposures and risks at this scale is complicated by the fact that many of the exposed populations have other goals in mind. Firefighters often see smoke exposure as part of the job, and citizens in the affected area are often willing to expose themselves to dangerous concentrations of smoke in order to protect their property and continue living their lives somewhat normally. Both populations have attitudes, such as machismo and complacency based on personal past experiences, that can lead to higher smoke exposures. Due to the highly variable nature of smoke in space and in time, exposures for these populations may be better understood through the deployment of portable monitors in impacted areas. This can help address several gaps in knowledge, including incomplete exposures assessments and understanding of the toxic components of smoke.

Populations in towns and cities that are near fires, but not directly impacted through burning, are affected primarily by exposure to elevated levels of traditional air pollutants, e.g. ozone and $PM_{2.5}$. These pollutants are typically assessed using fixed site permanent monitors or temporary monitors, satellite imagery, and limited use of modeling. Gaps for these populations include unsatisfying advice for health messaging around smoke events, and the lack of sufficient information to get the details of daily smoke emissions right, which hampers effective modeling of smoke exposures.

Populations far downwind of a fire, which can include whole regions of the continent (including Canada and Mexico), are impacted by relatively smaller incremental increases in $PM_{2.5}$ and ozone. These incremental increases are harder to attribute to individual fires, but because potentially tens of millions of people are affected, they can have a large impact on public health. In assessing these risks, it is important to be able to parse out the smoke impacts from daily fluctuations in the contributions from other sources. These types of attributions are typically done using a combination of modeling, satellite imagery, and source apportionment techniques. Gaps in these assessments include how to accurately create a counterfactual (what $PM_{2.5}$ would have existed in the absence of smoke), and sufficient daily emissions estimates for non-smoke sources to inform regional modeling of photochemistry.

Communicating risks to the people who need it is challenging. An analogy was provided of a meteorologist deciding whether to put out a tornado watch when no one is responding. To get people's attention, the meteorologist used Facebook to show a picture of him and his family readying their tornado shelter. The picture was widely shared and many in the community approached the meteorologist to say that the photo was the most helpful information they had gotten about the impending event. The lesson is that the public is more likely to respond to suggestions of what to do rather than abstract information disconnected from the real impact, more likely to understand the risk when they see a trustworthy figure taking precautions, and more likely to believe the risk when they can connect to the messenger on a human level.

Wayne Cascio, US Environmental Protection Agency ORD, Chapel Hill, NC
Dr. Cascio provided his perspectives on health risks from smoke exposures. There are basic things about the health risks of wildfire smoke exposures that we still do not know. These include which at-risk populations might be missed in traditional risk assessments, existence of health effects beyond pulmonary and cardiovascular, relative toxicities and health effects of emissions from different wildland fire fuels and different combustion conditions, relative risks from short term exposures to high concentrations and longer term exposure to lower concentrations, the potential for modification of risks by "stress," and specific accounting for the health risks and ecological benefits of prescribed burns.

At-risk populations may be those with chronic heart, vascular, lung, or chronic inflammatory diseases (such as diabetes or obesity), aged adults and children, and possibly pregnant women and infants. Given the high prevalence of chronic diseases in the U.S., this is a potentially large pool of at-risk individuals. Conditional susceptibility may also be relevant for smoke exposures. This occurs when the addition of external factors such as air pollution or stress increases the likelihood of cardiovascular or respiratory events including death in populations that are already at higher risk due to pathological changes in the heart or lungs.

Vulnerable populations include aged adults, children and pregnant women, and those with limited resilience, e.g. medically frail, dementia, respiratory dependence on oxygen, low socioeconomic status, or living near a source of chronic air pollution (e.g. near a roadway or port).

In light of these understandings about susceptible and vulnerable populations, there are several guiding principles regarding smoke risk. These include: to frame management decisions in the context of benefits, risks, burdens and likelihood of achieving better outcomes; interpret and apply scientific literature (environmental health, clinical and epidemiological studies), while recognizing limitations of the evidence; elicit and incorporate individual preferences into decision-making regarding interventions; consider the complexity of the intervention and its feasibility in making management decisions; and select interventions with the greatest likelihood of achieving designed health outcomes at an acceptable risk as defined by the individual.

Patricia Champ, US Forest Service, Rocky Mountain Research Station, Fort Collins, CO
Dr. Champ provided her perspective on the economics of improving public health outcomes during smoke events. Benefits of reduced wildfire smoke exposures are the product of the change in health outcomes times the unit value of the health outcome (which includes medical expenses, lost wages, averting and mitigating expenses, and disutility). We know that wildfire smoke makes people sick and can kill them. We also know there are economic costs beyond fire suppression (even though that cost is half the budget of the forest service), for example, the 2003 southern CA fires were estimated to result in $173 million to $173 billion in mortality costs (the range reflects uncertainty about value of a statistical life), while the direct costs of fire suppression were $124 million. Another example is the 2007 southern CA fires which resulted in $3.4 million in costs due to excess hospital and emergency department admissions related to wildfire smoke exposure.

However, there are very few studies in the US of the economic costs of wildfire smoke exposures. Most economic studies use cost of illness estimates (which do not capture lost utility), and assume no behavioral response to smoke. Some case studies observe high PM levels but no change (or decrease) in emergency department visits, and this may reflect behavioral modifications during smoke events that prevent either exposures or people going to the hospital.

In general, not much is known about averting behavior during smoke episodes. There is one study from the 2010 Station Fire in CA. Estimates are that the willingness to pay for one less symptom day is around $90 versus $3 daily cost of illness (which increases to $17 if the value of lost leisure is included).

To move forward in understanding the economic benefits of reducing smoke exposures, several improvements in cost of illness estimates are needed, including better estimates of the extent of the population exposed, better matched concentration-response functions linking smoke exposures to health outcomes, estimates of actual smoke exposures which include indoor and outdoor smoke exposures, better measures of lost wages and leisure time, and better estimates of medical costs, both total and out of pocket.

Improvements in understanding of averting and mitigating behaviors prior to and during wildfire smoke events is also needed, including the prevalence of different behaviors, why the

prevalence of behaviors differs, e.g. due to messaging, experience, or health, what are the different behavioral responses, and how the use of averting or mitigating behaviors change exposures and health outcomes.

Marilee Long, Colorado State University, Fort Collins, CO
Dr. Long provided her perspective on health risk decision making. There are several useful models of health risk decision making. The Extended Parallel Process Model proposed by Kim Witte provides a framework for tracking message components through message processing to outcomes, which include motivation for protection and adaptive changes or motivation for defense and maladaptive changes.

Health risk message processing requires an understanding of stakeholder risk perceptions of severity ("how bad is it?") and susceptibility ("how vulnerable am I?"), stakeholder response efficacy perceptions, e.g. "Will recommendations work?", and stakeholder self-efficacy perceptions, e.g. "Can I adopt recommendations?" On this last issue, there is also the concern that there are barriers to adopting recommendations, for example, parents may find it infeasible to stay indoors all day with young children.

Potential outcomes of health risk message processing include three cases:
1. Perceived threat and efficacy are high leading to a high motivation to control danger
2. Perceived threat is high, but efficacy is low leading to a motivation to control fear, and
3. Perceive no threat, so no motivation to act.

These potential outcomes highlight the importance of formative research to determine target audience risk perceptions as well as their response efficacy and self-efficacy for recommended actions. Messages developed based on strong formative research are more likely to result in target audiences adopting protective behaviors.

Question & Answer

In the model that you are using for cost of illness, for things like going outside to play, how are you modeling the economics?

> Used a survey question to get information on how people reduced leisure activities in response to wildfire, but this is an area ripe for additional studies.

In this new age of social media, how can we tailor our messages to be specific to different communities but also make them applicable at a large scale?

> Develop networks through leaders in the community (example of the meteorologist who got nothing done through televised announcements of tornado risks but saw greater responses when information was posted on Facebook). Important to study these change agents.

After a wildfire, we would like to evaluate what we did. We haven't been able to evaluate our outreach. Any guidance on how to evaluate that?

> Need greater access to medical records, administrative data, and pharmacy records. We need to go in and ask what people did. This isn't hard but is costly. Health care providers are trusted and a good place to send out the message.
>
> We don't just need the data and numbers, but need to look at the averting behavior. How money is spent perhaps? Past behavior can predict future behaviors. Health care providers also have good credibility – key endpoint as nexus to connect to individual people.

Day 1 Breakout Groups: Developing Problem Statements

1:00 pm

Based on the pre-workshop mind mapping exercise, the organizing team identified five areas to focus on during the Day One breakout groups. These five areas are:

- Assessment of risks from exposure to wildfire smoke
- Coordination between agencies and stakeholders
- Government agency interventions to mitigate exposures and health effects
- Improving air quality awareness – message content
- Improving air quality awareness – message delivery mechanisms

We assigned each breakout group the task of crafting a problem statement which includes four elements: 1) why is the issue important? 2) what is the current state of knowledge about the issue? 3) what is the desired state for the issue area? and 4) what is the gap that is preventing achievement of the desired state?

We assigned participants to breakout groups based on their identified preference where possible, however, in some cases, we asked if participants would be willing to change groups to provide a better balance either among areas of expertise or among different types of stakeholders.

Summaries of each breakout session, giving the highlights and general points that occurred during discussions, follow. In these summaries, we tried to capture the flow of the discussion, and have not corrected the content for factual inconsistencies, although in some cases, we provide a footnote where there are clear factual errors. Each group organized itself slightly differently, and as a result, the summaries reflect group organization in their discussions.

Breakout Group 1: Assessment of risks from exposure to wildfire smoke

Part 1: Within the context of improving communication and management of health risks from wildfire smoke, why is it important to assess the risks to individuals and communities associated with wildfire smoke events?

Understanding risks enables determination of proper behavioral responses. Understanding how much risk is attributable to smoke vs other sources can help with risk messaging for outdoor activities. Understanding the specific risks from smoke, rather than studies of $PM_{2.5}$ in general, can better inform risk management. Understanding the multipollutant aspects of air quality related to smoke is important, e.g. smoke affects both ambient $PM_{2.5}$ but also ozone. Understanding risk at a finer spatial and temporal resolution will help focus risk management efforts, as risks are not the same for everyone at every time

Aspects of risk that are important include understanding how risk is impacted by behavioral changes/adaptability/resilience. Understanding how interventional strategies at individual, community, and population levels will lead to more effective policies. Understanding which populations are most vulnerable to smoke exposures and risks can help target policies. Also useful to understand other impacts for example on wildlife, water quality, and biota. Addressing the social and cultural context of risk is also important to improve the effectiveness of policies.

Part 2: What is the current state of knowledge about the assessment of health risks related to wildfire smoke events? What does the existing research literature tell us about individual and community level risks associated with wildfire smoke exposures?

Currently available monitors and sensors are expensive and not easily deployed. There are currently some, but not enough, smoke monitors available. The desired state is an adequate availability of smoke monitors. There are air quality models available but none available at local and regional scale (defining local scale at <4 km). There is still uncertainty in current models.

We know smoke exposure is bad for health, but do not have a clear sense of how to quantify the risk. There is little knowledge of the chemistry and ground level effects of fresh vs aged smoke. We know more about urban particulate matter than PM from smoke, especially regarding health effects.

There are some planning tools being developed and some vulnerability assessments. In addition, we know something about the at-risk groups and populations. We currently rely heavily on studies of ambient $PM_{2.5}$ and ozone to understand risk.

We could do a better job of public health messaging. For example, we could use better information on the behaviors of the general population during wildfires. We could have clearer guidance on what people *should* do during wildfires. There are people actively trying to reduce their exposures who could be guided by better information.

The US Forest Service's primary risk focus is on safety during fires, e.g. preventing injuries and fatalities, rather than on reducing air quality related health impacts. Air quality and impacts are not the primary consideration in suppression, mitigation, and land management decisions.

Current information on air quality provided through the AQI are based on 24-hour averaging times, and rely on fixed site monitoring and national air quality models. Advisories are directly based on outdoor ambient air, and are not adjusted for the time people stay indoors or their activity patterns. There is no online resource that consistently puts together all $PM_{2.5}$ monitoring data, which makes it hard for modelers to incorporate that data in smoke forecasts.

There are only two existing studies on behavior during smoke events. Many people do not know they are vulnerable to smoke (including some firefighters).

Part 3: Where do we want to be in terms of our risk assessment capabilities and understanding of risks associated with wildfire smoke events?

A lot of information exists but has not been put together or synthesized. We need to improve communication between scientists and policy makers. As part of this, we need a philosophical change in how people make fire suppression decisions. This requires a change in worldview, and this has to happen by demonstrating the value of information about smoke health effects or the value in changing the fire management philosophy to include smoke effects. In the fire business, the focus is on economics, and that dictates budget priorities. By quantifying effects in economic terms, you can demonstrate a value proposition for the fire managers. For example, you could reference the Global Burden of Disease estimates of the worldwide mortality from biomass burning. Communicate science results in terms people can understand.

We want to see improved understanding of the toxicology of smoke (in various forms). We also need improved understanding of the chemistry of wildfires. Improved focus on mixtures rather than individual pollutants. Better understanding of the relationship between health outcomes and smoke exposures will improve the ability estimate economic costs of exposures. We also need to understand the social costs of averting behaviors, for example, there may be a high cost to staying indoors or deciding not to go to work because of smoke concerns. Availability of models of risk assessment and apps that incorporate non-smoke risk factors, including vulnerability assessments and planning tools.

Improved and expanded air quality monitoring and modeling across the US, would be facilitated by availability of a 1 km^2 weather grid across the US., and improved low cost air quality sensors and reliable satellite technologies.

Consistent risk messages that integrate messages about behaviors and actions would be good; for example, exercise for health, but do not go outside to run during fire for health. It would be good to have better approaches for increasing geographic specificity for communication with communities in mountainous areas (could have smoke in one valley but if the sensors are in

another valley then the smoke is not picked up). Risk information is targeted to include subpopulations that are especially susceptible to wildfire and smoke.

Ideally, smoke effects will be integrated in land management and risk assessment decisions. In addition, information will be available on how many people are exposed during a fire and what types of health effects are experienced. Sensors will be used to obtain this information, along with information on activity patterns during smoke events. Information on smoke exposures and health effects will be easily available to the public. Tools will be available to access smoke and health information, bring data services together and make data more accessible to the public. Analyses will be available to characterize the costs of smoke exposures and the full economic impact, which includes both human health and the environment.

Part 4: What is the gap that is preventing informative assessments of health risks from wildfire smoke events? What are the consequences of not addressing these gaps?

Gaps include:

- Communication of science
- Data on the economic costs of smoke exposures,
- Understanding of toxicology and chemistry
- Behavioral responses to smoke – economic and social cost
- Finer resolution models (air quality and weather)
- Dearth of reliable monitoring- sensors, satellites
- Understanding mixtures in a risk assessment framework
- Integrating smoke health effects into land management and risk assessment

Breakout Group 2: Coordination between agencies and stakeholders

Part 1: To improve public health outcomes related to wildfire smoke events, why is stakeholder-agency coordination important?

The public has to trust the agencies before they will respond to the risk messages provided by these agencies. Consistency of messages across agencies is necessary or the public will ignore all warnings from all agency sources and will not change behavior. Building relationships is necessary for successful coordination with stakeholders.

Coordinated response and messaging allows agencies to combine resources (FTE, money, expertise, equipment, etc.), achieve more (one agency is often not equipped to do everything required), effectively assess the full scope of a problem and the real impacts, respond efficiently, and reduce redundancy. More effective and consistent communication can lead to better outcomes considering the issue is complex, and will help improve understanding of the issue across all authorities involved in managing the risk.

Protection of public health requires commitment by all groups, especially considering that fires and smoke do not observe geopolitical boundaries and may affect many overlapping jurisdictions. Lessons learned can and should be shared between agencies.

These themes are related to agency communications, but it is important to assess who are stakeholders and how can they better communicate and coordinate with us. Stakeholders will change based on the spatial scale of a fire. Stakeholders can be local government and/or community groups (e.g., Red Cross, religious/civic groups), but what about the general public? If there is a wildfire in Washington affecting Idaho, who do we coordinate with? Crossing state boundaries increases the complexity of interactions.

When and how we coordinate is also important. Coordination should happen before, during, and after an event. Need better understanding of the mechanisms for coordination and the levels at which coordination should occur.

Part 2: What is the current state of knowledge about how agencies and stakeholders coordinate around wildfire smoke events, especially related to communication and management of health risks? What does the existing research literature tell us about ways that improved coordination between agencies and stakeholders can lead to improved health risk communication and management?

Prescribed fires are necessary, but there is a need to manage prescribed fires better by communicating the smoke risks. Currently, there are inconsistencies and duplications in risk communication efforts (including messaging). Messaging is often bland and uninteresting to stakeholders, resulting in lower degrees of response. Digital communication is an improvement but also can provide information overload and does not always utilize information that has been vetted for accuracy. There are also technology challenges as well, including the varying quality of equipment and stakeholder access to equipment.

Rapid response to health risk messages is currently difficult. Not all parties, including both stakeholders and agencies, are participating or participating fully in developing and delivering risk messages. Some stakeholders may not have total buy-in.

Federal, state, and local groups are all developing different messages and approaches to risk communication. There is a lack of clarity about roles and responsibilities for each agency or group. Agency commitment is necessary but is often not there. Commitment needs to come from the top. This requires increased awareness of the issue by senior management awareness and commitment to action. This appears to be occurring due to the increase in the number of large wildfires in recent years. There are good examples of smoke risk communication that we can draw upon and use as models, and these will need to be identified and described.

Amenity migration will bring new connections to areas that are at risk from smoke. The risk to forested communities is increasing each year as populations increase in rural areas. These new

people are not aware of the precautions or strategies that need to be undertaken in high risk communities.

Risk communication by agencies is very reactive. There is a basic level of response, but this is not able to effectively address public concerns. The budget for risk communication and response to risk is limited.

Part 3: What is the desired state of coordination between agencies and stakeholders around wildland smoke events?

Successful coordination between agencies and stakeholders to reduce the impact of smoke on public health. Be proactive. Create messages to motivate behavioral change, including outreach materials based on the Wildfire Smoke Guide. Pooling of resources including expertise, money, equipment, and time.

Successful coordination should include consideration of local concerns and continual solicitation of input from the stakeholders. Tailored and transparent collaboration and communication approaches should consider the full range of agency and stakeholder needs. Agencies consider opportunities to educate and empower health practitioners at the local level to assist with messaging.

Roles and responsibilities for all responsible agencies are clearly identified. All agencies are committed and take ownership of the response. Consistent experienced personnel work together. There is a shared understanding of risks, with a clear consideration of explicit tradeoffs.

Communities and individuals know where to go to ask questions and receive accurate information to inform their actions. Scientists and technical staff inform decision-making with appropriate consideration of uncertainties.

There is sincere, genuine, and ongoing communication before, during, and after a smoke event to evaluate lessons learned, with a focus on identifying what does and does not work.

Part 4: What are the gaps that are preventing ideal levels of coordination between agencies and stakeholders? What are the consequences of not addressing these gaps?

- Money and committed staff time
- Lack of research to support change without economic stress
- Lack of knowledge about best practices
- Lack of guidance on how to use data from different types of air quality monitors
- Need guidance on forecasting AQI for wildfires
- Staff time and expertise limitations
- Lack of commitment to the problem by senior level officials
- Lack of data to inform balancing trade-offs

- Lack of enhanced IT connections; data incompatibilities
- Lack of pre-season fire outreach materials
- Lack of trust of agencies by the community and public stakeholders
- Not meeting the public need for more information
- Lack of equal buy-in or ownership of the problem
- Lack of understanding of emissions from both prescribed and wildland fires and their effect on human health
- Lack of consistent messaging from all agencies

Draft Problem Statement:

Coordinating between agencies and stakeholders is important because many groups are involved. Consistent messaging to the public creates opportunities to reduce exposures and improve public health and well-being. We have made great progress but still have inconsistencies. Commitment between agencies and stakeholders is variable and often unclear. Commitment by senior leaders and ownership of the problem by all involved can help to provide sincere and genuine engagement with community stakeholders. By pooling resources and creating an organized messaging strategy, the public health of communities affected by wildland fires can be improved.

Breakout Group 3: Government agency interventions to mitigate exposures and health effects

Part 1: To improve public health outcomes, why is it important to understand government agency interventions to mitigate exposures and health effects?

The need to mitigate the impacts of smoke exposures is increasing. Government agencies have a responsibility to help in mitigation efforts, including providing guidance. However, the government has to balance potentially conflicting needs, for example, avoiding smoke exposures, but also recognizing the need for prescribed burns. In some cases, there may be shared goals, e.g. reduced public exposure to smoke risks, but in others, there may be differences, e.g. air quality managers in some cases may not recognize the need for prescribed burns.

Tension exists between the primarily ecological focus of prescribed burns, versus the public health focus of air quality managers. The Forest Service focus has been on trying to educate communities about the benefits of prescribed fires for ecosystems, while also building up public acceptance of the smoke that accompanies those prescribed fires. This is conflict with the messages from EPA about the health risks posed by smoke exposures. It is important to recognize that there may be a tradeoff between smoke risks from prescribed fires and wildfires, e.g. “how do you want your smoke?” Prescribed fires can be implemented a bit at a time, while wildfires are uncontrolled and can result in large, sustained smoke exposures and catastrophic damages to homes and property. Government has a large role in managing these risks, but is not

trusted. We need to understand agency interventions to be able to increase trust. There is also a need to understand what information and interventions the public expects, given the new era of information availability – do people expect more education during a fire/smoke event?

People want help and expect the government to provide resources, but also do not trust the government to be effective because of a lack of resources and capabilities, and is not transparent about their ability to execute.

Part 2: What is the current state of knowledge about government agency interventions related to wildfire smoke events? What does the existing research literature tell us about government interventions related to smoke (or related events) and their impact on exposures and health effects?

There is increasing knowledge about the serious health impacts of smoke. This can lead to additional regulations, however, more and better communication is needed. Authorities should consider alerting populations to the need to evacuate not only when there is the potential for property damage from fires, but also when there are potential health risks from smoke. Current evacuation protocols are poorly implemented. People are evacuated to areas that may not be safe from smoke exposures. They may be subjected to higher smoke exposures and also have the added stress due to the evacuation.

There is a focus on the regulatory aspects of smoke, e.g. does it cause a violation of the standards. Local governments only pay attention to these violations because of perceived penalties, not based on health risks. EPA is not seen as a driver in many smoke events because those events are thought of as exceptional events that do not contribute to regulatory violations. The CDC is primarily concerned about asthma during these events, and not overall health risks from smoke. Prominent health organizations such as the American Lung Association and American Medical Association have not provided guidance on health risks during smoke events. Outreach to these organizations may be occurring but needs to be increased.

Some interventions are currently occurring, including: air filtration, evacuations, encouraging people to stay indoors, and communicating to the citizens the resources that are available to them. However, the degree of implementation is insufficient.

Agencies are in some cases providing inconsistent information in the same location, or not fully coordinated or complete information. Some of this may be caused by gaps in the science relating smoke and health impacts. The communication tools related to air pollution, e.g. the AQI, are general tools intended to look at everyday exposures to ambient air pollution. This may not be as useful during a smoke event. More information is needed on risks for susceptible populations.

Part 3: What is the desired state with regards to government agency interventions related to wildfire smoke events? What types of interventions might be considered as appropriate to reduce or mitigate smoke exposures and improve public health outcomes?

Elements of a desirable state include regular coordination and communication amongst agencies and up to date master lists of experts and contacts. In addition, EPA should be more engaged in a wider set of multiagency fire meetings.

Greater ties between fire/smoke mitigation and the climate change conversation. Better assessments of the effectiveness of current interventions. Increased focus on the process for engaging communities. Availability of clear information and guidance about what agencies can do. Better understanding of the impacts of prescribed burns – are they better or worse in terms of public health compared to catastrophic fires?

Part 4: What is the gap that is keeping government agencies from implementing interventions that can reduce smoke exposures and improve public health? What are the consequences of not addressing these gaps?

There is a lack of information on which government agency interventions are effective. We do not have sufficient information on what individuals choose to do in response to risk information and why. We also need better information on community dynamics – what are communities doing compared to individual citizens? We also need better information on the effectiveness of prescribed fires as potential mitigation tools to reduce impacts from wildfire smoke events.

Agencies also need better monitoring of both health and environment, including better access to surveillance type medical records, chemical speciation of smoke, and attribution monitoring to determine sources of smoke related air pollution.

[Note: this breakout group did not construct a draft problem statement]

Breakout Group 4: Improving air quality awareness – message content

Part 1: To improve public health outcomes, why is message content important to improving knowledge and awareness about air quality?

Message content is important for several reasons, including increasing awareness, reducing exposure, correctly motivating actions, avoiding unnecessary stress, avoiding "false sense of security." Messages also provide information to decision makers and the public and identify ways to protect the public. Good messages provide communication and translation of information to the public. Good messaging requires understanding of the types of behaviors that are being promoted.

Common themes of discussion:
Good messaging avoids unintended consequences, e.g. expecting a message to affect behavior in a positive way, but instead results in a different action which could be counter to the intended goal. Messages should be explicit about the desire for individuals or communities to change behaviors.

Overall goal of communication is to improve public health. This does not necessarily require changes in behavior (although it usually does). Good messages give people information so they can assess their own risk, and make their own decisions regarding protective actions. Message content should recognize that there are different audiences, e.g. communities, health care professionals, government, that may respond to different types of messages. Likewise, there are different situations in which specific types of messages may be more effective. Different types of decisions may also need different messages. For example, the information needed by individuals to make decisions about protective actions likely differs from the information needed by communities, public health officials, or health care professionals. A key part of any messaging is to make sure that the audiences understand that during smoke events, air pollution is high.

Part 2: What is the state of knowledge and awareness of air quality in different types of communities and populations? What is the current state of message content? What does the existing research literature tell us about messaging related to air quality information and how it is currently used? Who (organization) currently translates data into information in health risk messages?

Currently, information is provided with little context for how it should be used. We expect that audiences will know what to do. The assumption is that people aren't getting the message rather than getting the message but not responding. We do not know which populations we are good or bad at targeting with messages. Risks are not well understood or communicated. There are many competing messages of varying quality, with general public statements and generic things people can do, but not targeted to specific audiences.

Common themes of discussion:
Currently available information and messaging includes AirNow, the wildfire smoke guide, state smoke blogs, and the national weather forecast (hourly—forecasted 48 hours). There is lack of agreement on the appropriate content for messages, reflecting incomplete understanding of the audiences for the messages. Communicators should exercise caution in developing targeted messages because this can lead to lack of trust if different people are getting different messages without understanding why. Currently, messaging is much more generic, with little targeted messaging.

It may be necessary to customize messages and allow audiences to access multiple tiers of information, for example, maps, narratives, and tables. Users that are more sophisticated will benefit from detailed technical information beyond high-level messages. When choosing the primary message (top level), focus should be on a "hook" that draws attention and leads to actions, for example "if you see smoke in the sky, check out the AQI".
Part 3: Where do we want communities and individuals to be in terms of their awareness and knowledge of air quality especially during wildfire smoke events? Where do we think messaging about wildfire smoke needs to be?

Messages should provide accurate and motivating information to protect individual and community health. Smoke can change over distance and time. As a result, we need actionable

statements that reflect current and projected smoke conditions to protect health based on more accurate predictions of fires. Messages should be consistent and culturally relevant for the intended audiences, messages based on research, short tangible messages or "jingles", and because people respond and prepare appropriately based on message content, clearer messages at different times of the day

Common themes of discussion:
Clarity in messages is necessary. Focus on simple and high-level messages that strike the right balance. Develop targeted messages based on improved spatial and temporal information on smoke. Messages should be tailored to address shorter and longer wildfire events. Consider using lessons from messages about weather conditions in developing messages about smoke, taking into account the less predictable nature of wildfire smoke. Important to evaluate the effectiveness of the messages, however, it is difficult to get health information tied to many events, especially wildfires.

Part 4: What is the gap that is keeping communities and individuals from increasing their knowledge and awareness of air quality? What is the gap in the way that air quality messages during smoke events are currently formulated and where they need to be? What are the consequences of not addressing these gaps?

What is the most appropriate response to smoke? Agencies need to coordinate around development of messages. Evaluation of existing messaging and development of more effective messages. Evaluation of barriers to adoption of improved messages. Assessment of social media capability and capacity issues. Assessment of which languages and media formats are most likely to result in effective messaging. Development of improved resolution of smoke predictions, including at the neighborhood level. Messages would be better informed by a comprehensive assessment of risks due to wildfire smoke. Development of ready-made materials (fact sheets, quotes) to enhance the ability communicate quickly during events.

Common themes of discussion:
Public involvement in the process of developing communication tools and message content is needed – we need better understanding of public needs. We need more data on the effectiveness of different communication strategies. Regulations may be preventing development of more coordinated, more effective messages, however, local agencies may be able to communicate more effectively or enhance actions in response to messages.

Strategic partnerships can be used to maximize the capabilities and resources of each partner. However, funding and manpower are always gaps.

The ability to provide messages based on accurate forecasting may be limited by air quality monitoring coverage. We also need monitoring of the behavior of fires to know what fire conditions will be like tomorrow. Current approaches to monitoring/modeling are not fast or

good enough. We need to be able to update forecasts dynamically with multiple sources of information.

How can messages enable individual communities to mitigate smoke risks. Information needs to relevant and interesting. Providing bland information can potentially be worse than no information – information needs to be actionable. Good examples of actionable messages need to be developed. The information needs to be credible but also easily digestible (e.g. "sound bites").

Draft Problem Statement:

Public health messaging about wildfire smoke is critical to enable different audiences to make appropriate decisions and reduce potentially harmful exposures. It is currently hard to translate messages into actions. Messages are too broad to be useful or relevant and too technical to understand. We want people to respond appropriately to smoke risks but this is challenging because we are not aligned on what that means. Depends on so many different things like audience, culture, health status, and proximity to smoke.

Breakout Group 5: Improving air quality awareness – message delivery mechanisms

Part 1: To improve communication and management of risks from wildfire smoke, why is it important to understand and improve mechanisms for delivering air quality and risk messages to individuals and communities?

Citizens need high quality, clear information so they can make better decisions including taking actions to protect their health. The goal is to enable people to avoid health problems due to poor air quality associated with wildland fire smoke events. Improved message delivery enables authoritative sources to provide timely personalized, meaningful, actionable information to people via their normal means of receiving information. Improved message delivery can more effectively influence behavior change and reduce loss of property and life. Improved delivery mechanisms can improve uniformity of messages.

Different delivery mechanisms can enable communicators to reach different audiences. Focusing delivery at different scales is important, e.g. AirNow is targeted nationally, but more personal information can be more effective at changing behaviors.

Common themes of discussion:
Context, timing, and timeliness of delivery is important. Consistent and uniform messaging may be helpful (however, this may conflict with the desire for personalized information).
Consideration of how much information can be delivered using different mechanisms may be important, for example, can a mechanism deliver videos, infographics, real time streamed data?
Important to recognize key components of mechanisms including constraints (money, people,

resources, channel capacity, trust), outcomes (behavior change, improved public health), implementation (delivery, timing/timeliness, consistency, specificity)

Summary:
Individuals and organizations need high quality (timely, consistent, uniform, accurate) and clear information so they can take action and make decisions to help them protect their health

Part 2: What is the current state of knowledge about mechanisms to deliver air quality (or other related topics) and risk information to individuals and communities? What does the existing research literature tell us about characteristics of different delivery mechanisms, e.g. cost, effectiveness, accessibility, etc.?

Many different organizations use different methods to communicate risk information, including social media, blogs, internet, press releases, emergency apps, news programs. Specific examples include AirNow, state websites, the Weather Channel, and wildfire guides. Sometimes communications can be slow and not in real time, and can be lacking health related information, or specific actions that can be taken to reduce risk. There is currently lack of trust in government agencies and authorities. Public expects messages to reflect what they can see, e.g. when its hazy outside or smell funny, they are looking for messages from authorities that address the perceived smoke problem.

Common themes of discussion:
Digital platforms, pushing data to audiences vs them having to pull data from sources. For example, with AirNow, users have to seek it out, rather than having messages delivered. With platforms like Facebook, the messages are pushed out to the audiences through news feeds. Overall, we are currently mixed, with slightly more emphasis on pull technologies. Audiences often need to make the first step to get information pushed to them, e.g. signing up for a newsletter, following a group on Facebook, even logging in on Facebook. A clearer definition of push vs pull data is needed, many sources seem to include both types of approaches.

There is also a mix of static vs dynamic information sources. Dynamic sources can include real time updates, and platforms where there is a 2-way interaction, which allows information to flow in both directions. Movement is away from static and towards dynamic communication. There is also variability in the types of information provided, at times the information is not actionable, partly because the preferred actions are not delineated in the message.

Currently there is a mixed state of trust, the level of trust varies by the type of authority or agency. This is partly because there is a multitude of authoritative sources, not all providing consistent messages. There is often confusion on which source should be seen as authoritative in a particular situation. In these cases, individuals become confused as to whom they should listen.

Summary:

Currently there are mixed modes of static (for example print and billboards, fact sheets) and dynamic delivery mechanisms provided by a variety of authoritative and popular sources with varying degrees of certainty and effectiveness.

Part 3: What do we want the state of delivery mechanisms for air quality and risk messages to be?

Delivery mechanisms should incorporate the ability to dialogue with citizens, reach both key audiences and the broad population, and be trusted and effective. Multi-mode capabilities would allow for flexibility and easier adaptation to changing smoke conditions. Data provided through different mechanisms should be free and open and seamlessly integrated across different mechanisms. Delivery mechanisms should provide guided information on impacts from smoke and specific actions to take for each type of individual. Effectiveness of the mechanism should be evaluated based on how well the messages are reaching intended audiences, and potentially how effective the messages are in affecting behavior.

Summary:
In the desired state, there is appropriate matching of the delivery mechanism to the tailored messages and selected audiences.

Part 4: What is the gap that is preventing or hindering development of mechanisms that effectively deliver messages that lead to greater air quality awareness, reduced smoke exposures and improved public health outcomes? What are the consequences of not addressing these gaps?

How do people know there is a smoke problem? How do we address the gap between individuals or communities knowing that air quality is bad due to smoke, and knowing what to do to reduce exposures or health risks? More information is needed on which delivery mechanisms are most effective for particular audiences, even more basic information is needed on target audiences and their information needs, including where and how they access information currently. Development of more “push” based delivery mechanisms instead to continuing to rely on people pulling their own information. In order to do so, we need to find access points for pushing information. We need to better understand how to provide information even when individuals are not aware that they need it. We need to be able to exploit currently used information routes (such as Facebook). In some cases, access points may not exist yet and will need to be developed.

Summary:
More information on existing delivery mechanisms, target audiences, and the potential of push technologies is needed. We need to understand the right delivery methods for specific audiences and identify and develop access points to push messages.

Draft Problem Statement:

Individuals and organizations need high quality delivery systems to take actions and make decisions to protect public health. Without the high quality message delivery systems people cannot take action and make decisions. Currently, messages are delivered via a mixed mode of static and dynamic delivery mechanisms provided by a variety of authoritative popular sources to varying degrees of certainty and effectiveness. The desired state is an environment of seamless data integration and availability so we are able to appropriately match delivery mechanisms to the tailored messages and selected audiences. More information is needed to determine the right delivery mechanisms for specific audiences, and to identify and develop access points to push/pull information.

Fire Talks, Poster and Demos Session

4:10 pm

At the end of Day 1, a Poster and Demos Session was held. The session was preceded by brief "Fire Talks" introducing the posters and demos for later discussion. During the poster session researchers had an opportunity to interact with other participants and discuss their own research related to wildfire health risk communication. These posters are available upon request.

First name	Last name	Poster or Demo Title
Neal	Fann	Quantifying the burden of wildfire-attributable PM2.5 concentrations in the U.S. between 2008-2012.
Ian	Gilmour	Comparative Study of Emission Factors and Mutagenicity of Red Oak and Peat Smoke from Smoldering and Flaming Combustion
Amanda	Kaufman	EPA's Air Sensor Toolbox for Citizen Scientists: A Resource for Community Air Quality Monitoring and Mapping
Kris	Ray	Confederated Tribes of the Colville Reservation Wildfire Smoke Educational Outreach
William	Slocumb	Demo of Time-enabled Web mapping application for Gateway NRA: http://go.ncsu.edu/gatealarmboxes
Ivanka	Stajner	NOAA's air quality predictions
Lauren	Thie	Mapping Health-Related Vulnerability to Wildfire Smoke in North Carolina
Ana	Rappold	Demo of SmokeReady App and Poster of Background Research

Day 1 Output - Final Problem Statements

Following the report outs from the breakout groups, the workshop team developed a set of draft problem statements, which we provided to the workshop participants for comments and edits. The team then produced a final set of problem statements which are provided below. Following each problem statement, the team also provided a set of questions to frame the discussions in the day 2 breakout sessions on development of research and technology directions.

Assessment of Risks from Exposure to Wildfire Smoke

Problem Statement;
The "assessment of risk" is necessary in order to determine which communities and individuals are vulnerable to smoke exposures. The assessment of risk also improves our understanding of how both exposures and risks have increased as a result of more frequent wildfires, in addition to a larger portion of the population bordering on areas at higher risk for fire. Current risk assessments rely on studies that observe non-smoke specific PM health effects, or do not consider the effects of smoke in land management decisions. The desired state includes assessments of health and ecological risks that are built upon better characterizations of integrated exposures to smoke in the past and present, while informing the public of effective behavioral modifications and intervention strategies. Improved monitoring and models at finer geographical scales will improve assessment of exposures that, when combined with research on health and ecological impacts of smoke (and their respective economic costs), can lead to better understanding of those behavioral modifications able to reduce exposures and related impacts.

Things to consider when developing research questions:

- How can we improve monitoring and models to better characterize smoke at finer geographical scales?
- What types of health, ecological, and economic research is needed to better understand the appropriateness and effectiveness of potential behavioral modifications that may reduce smoke exposures and impacts?

Coordination between Agencies and Stakeholders:

Problem Statement:
Coordination between agencies and stakeholders is important because it is necessary to have consistent messaging across the variety of groups involved in order to build trust with the public, reduce smoke-related exposures, and improve public health. Currently, there are have been examples of effective coordination, yet in relatively isolated instances across the country. Wavering commitment of senior leaders across various agencies and stakeholder groups makes it difficult to provide consistent communications and responses, given the rapidly changing landscape of information availability. The desired state is a cycle of coordination characterized by: sustained and committed engagement on smoke-related responses, specific actions that are

clearly and consistently articulated and can be implemented at the community level, and a dedication to balancing the missions and needs of agencies and stakeholders respectively. Overcoming the lack of commitment at senior levels of agencies, coupled with low levels of trust held by stakeholders, will require expanding and strengthening coordination between agencies and stakeholders by increasing shared ownership of the problem and solutions; showcasing success stories; and providing more, high-quality information to the public on emissions, air quality, health risks, and effective actions.

Government Agency Interventions to Mitigate Exposures and Health Effects

Problem Statement:
In light of different goals and missions for fire management, government agencies have an important role in developing interventions given their access to resources, mission, and responsibility to protect public health and welfare. The importance of this role and mitigation has increased as the population at risk has increased. Currently the limited information on the effectiveness of interventions, and data and science gaps are further exacerbated by the lack of EPA resources and presence in decisions on wildfire management, leading to inconsistencies in the information provided to the public. The desired state is to achieve effective interventions that minimize public exposures to smoke via clear, fact-driven, risk-based communications and guidance on actions, integrated prior to smoke events, provided through coordinated interagency communications. Achieving this will not only require consistent, high quality information on health impacts during smoke events, chemical characterization of smoke, and sources of smoke; but also requires information on 1) which interventions, including fire management decisions, are most effective at reducing exposures and risks 2) what information individuals choose to pay attention to, act on, and why and 3) what communities as a whole do.

Things to consider when developing research questions:

- How do we assess the effectiveness of different types of government agency interventions in reducing smoke exposures, and thus human and ecological impacts including: communication strategies, fire management strategies such as prescribed burns, and evacuations?
- How can we assess the types of information that are most effective in reaching and inducing individuals to adopt health protective behaviors to reduce smoke exposures and health risks?
- How do we better understand what communities do that lead to reductions in smoke exposures?
- What information on health impacts during smoke events, chemical characterization of smoke, and sources of smoke can improve the design and effectiveness of interventions?

Improving Air Quality Awareness: Message Delivery Mechanisms

Problem Statement:
Individuals and organizations need high quality message delivery systems so they can take action and make decisions to protect public health. Currently, we have a mixed mode of static and dynamic delivery mechanisms provided by a variety of authoritative and popular sources with varying degrees of certainty and effectiveness. An environment of seamless data integration and availability is needed to appropriately match delivery mechanisms to the tailored messages and selected audiences. More information is needed to determine the right delivery mechanisms for specific audiences and to identify and develop access points to push and pull information.

Things to consider when developing research questions:

- How do we identify effective message delivery mechanisms appropriate for different audiences?
- What are the most appropriate access points to push information to different audiences?
- What are the most appropriate access points to pull information from different audiences?

Improving Air Quality Awareness: Message Content

Problem Statement:
Public health messaging (occurring before and during wildfire smoke episodes) is important so that different audiences can make decisions to reduce potentially harmful smoke exposures and negative health effects. Currently this messaging can be too broad to be actionable, or too technical for certain audiences to understand. The messaging may need to be tailored for certain audiences according to their culture, health status, and/or vulnerability so that the individual may respond most effectively during a smoke event. The desired state includes message delivery that is clear, consistent, actionable, and audience-tailored, while incorporating accurate, spatial and temporally resolved information for short or long-term events. To achieve this, there needs to be greater consideration of spatial and temporal factors, as well as the thoughtful inclusion of community voices as the messaging is being developed. The messaging should also be supported by improved monitoring data, more accurate and better resolved prediction information, enhanced understanding of health impacts, and include specific actionable recommendations.

Things to consider when developing research questions:

- How do we reach out to communities to include their knowledge and concerns in developing messages?
- How do we reflect varying spatial and temporal scales of exposures and impacts in developing messages?
- What improvements to monitoring and modeling of smoke will lead to improved messages?

- What type of additional information on health impacts of smoke will lead to improved messages?
- What types and forms of recommendations for specific individual or community actions should be included in messages to reduced smoke exposures and health impacts?

Workshop Day 2:

Overview

The second day of the workshop was focused on two activities, the first was a set of presentations about how technologies might be developed and applied to improve risk communication about smoke exposures. The second activity was a set of breakout groups focused on the question of what research and development directions could be relevant to address the gaps identified in the problem statements developed in the Day 1 breakout groups. The Day 2 breakout groups were in 3 areas: Air Quality Awareness: Message Content and Delivery Mechanisms, Government Agency Interventions, and Assessment of Risk from Exposure to Wildfire Smoke. Based on the day 1 breakout groups, we recognized that coordination between agencies and stakeholders would be an important component of all of the research areas, and thus we did not have a separate breakout group on that topic. Breakout groups focused on messaging were also consolidated. In addition, there was a breakout group focused on providing feedback to Dr. Rappold on the SmokeReady app, as the research the app was designed for was part of the impetus of the workshop.

Technology Presentations

8:45 am

Overview and Discussion of "Smoke Ready" App: Ana Rappold, US Environmental Protection Agency ORD, Chapel Hill, NC

Dr. Rappold provided an overview of the proposed SmokeReady study. It is important to communicate smoke impacts on health for a number of reasons. These include the increasing incidence and severity of large fires around the globe. As emissions from other sources of PM decrease, relative contributions of fire-related PM will increase. Many communities are affected by periodic and transient exposures to smoke from fires. Are there effective public health risk communication strategies that can address air quality during smoke events?

The most recent U.S. EPA 2011 National Emission Inventory estimates that 41, 47, and 31 percent of $PM_{2.5}$, black carbon, and volatile organic carbon emissions, respectively, are associated with agricultural, wild, and prescribed fires combined. Over 30 million people are exposed to annual daily average fire-related $PM_{2.5}$ of between 1.5 and 4.5 $\mu g/m^3$ (compared to the annual standard of 12 $\mu g/m^3$). Many communities do not have the resources to address these air quality issues.

The full title of the project is “SmokeReady Crowdsourced Study”. The study is centered around the development of a smartphone app for public health risk communication during smoke episodes. The objectives of the study are 1) determine the magnitude of the health burden from smoke in the population at large, 2) examine health risk communication strategies that influence individuals’ behaviors and reduce the public health burden during smoke episodes, and 3) quantify the economic value of avoiding health outcomes associated with smoke exposure.

The plan is to launch the app at the beginning of the 2017 fire season. The app uses the AirNow system to convey air quality to the user. AirNow is EPA’s system for communicating the current and forecast AQI. AirNow is a popular and recognizable website. However, while it provides up to date information on air quality in a general area, it does not tell us about the likelihood of a smoke exposure, how long it will last, and how it will impact the health of an individual.

Secondary objectives of the study are to 1) understand whether messaging strategies are equally accessible to all segments of the population and whether they reach the most vulnerable/at-risk segments of the population, 2) evaluate whether health messages are clear and understandable to a wide audience, 3) determine the utility of health messaging strategies to decrease health burden from smoke, and 4) identify strategies that promote and incentivize health-protective behaviors.

Participants in the study will receive smoke model predictions and forecasts, satellite imagery of smoke, and public health messaging. Gamification (i.e., using game mechanics to motivate) will be used to encourage participants to learn more about air quality and health protective behaviors, and promote desired behaviors. Investigators will receive demographic profiles of users, results of a weekly health survey and behavioral survey, app usage statistics, and a scorecard on gamification compliance behavior.

Some aspects that might be discussed in the SmokeReady breakout group include: community outreach opportunities, study design, e.g. are we asking the right questions, what is important in your community, behavioral incentives, identification of additional resources/info/data for users, and opportunities for phase II of the project - identify communities where health behaviors can be tested more extensively.

App Development: Infrastructure & Capabilities for Effective Community Engagement: Jason Geer, Weather Company, Atlanta, GA
Mr. Geer spoke about his work with the Weather Company in developing apps to engage with communities about weather related risks. He began by noting that there exists a wealth of current technologies for sensing air quality, and that waiting for the perfect solution misses important opportunities.

The focus of app development should be on users of the information, e.g. the who, what, when, where, and why? Who: citizens, agency decision makers, etc. Given this, who are the best authoritative sources to deliver information; this may differ by geography, and may in some cases focus on scientific authorities, or using celebrities.

What: User focused messaging, making data meaningful and actionable. What questions do people have? Is someone aware of this? Who is in charge? What is being done? Need to understand severity, urgency, certainty, and duration of air quality events.

When: Communication should occur before, during, and after an event. Updates should be provided to enable people to plan for today and tomorrow.

Where: Change is best enabled when you reach people through their usual routines, for example, changing commuting patterns, alerts on mobile phones, smart watches, etc.

Why: Communication should educate people about risks and impacts and why they should take actions.

How: How will authoritative sources submit data and information about air quality and potential risks? How can the data be formatted to be easily accessible, understood, and used by others? Using standard messaging formats (such as the Common Alerting Protocol, JSON, XML) can help.

How can developers access the data? Should promote a free and open data policy, use push/pull restful API services, and use app development platforms such as: the NOAA Big Data Cooperative Research and Development Agreement, IBM Bluemix, and the Office of Science and Technology Policy's Partnership for Resilience and Preparedness.

How can users be part of the solution and provide information and insights to help improve apps? Users can submit information through the apps, e.g. address, age, health conditions, etc. Users can also verify observations, e.g. confirming presence of smoke. Users can provide feedback and comments through an established process. Key is how to get users to use apps and websites.

We need to enable an open infrastructure to encourage dissemination of risk information. This infrastructure has a number of key elements. The initial element is identifying alerting authorities (individuals charged with recognizing a hazard/risk and altering a risk communication system). The next element is a set of publishing tools, which are employed by authorized users to create and approve information and alerts on a platform that attributes the alerting authority as the source of the information and distributed the information to a hub. The third element is a hub that enables publishers to post information and allows subscribers to receive information from the alerting authorities. The fourth element is the set of subscribers and citizens who will receive information and alerts from the authorities through various mechanisms such as radio, text messages, email, television, or mobile apps.

In the future, it may be possible to integrate smoke information based on the user context and activities, for example, runners might want to set preferred running conditions that include air quality levels. In addition, future apps might include the reporting of smoke information by citizen scientists.

Keynote Speaker
9:15 am

Greg Fishel, chief meteorologist for WRAL-TV in Raleigh, NC
Mr. Fishel spoke about his experiences as a meteorologist for a TV station in a major metropolitan area (Raleigh-Durham). Warnings are important communications. Tornado warnings get people's attention the most quickly, because they are perceived as the most dangerous and imminent threat. However, there is a high false alarm ratio with tornado warnings because of the dynamic nature of storm systems. Meteorologists have to be concerned about the "Cry Wolf" syndrome, but because of reliance on data and forecasts, there will always be a high probability of a false alarm. The message to audiences is "Don't be mad, be thankful!" When the costs of taking protective actions is relative low and the costs of inaction are high, people should welcome more protective warnings even when there is a relatively high chance of a false alarm – 75 percent of tornado warnings are false alarms.

Part of the reason for false alarms is the geographic specificity of warnings from the NOAA weather radio service. It is county based, which leaves a lot of land area to cover for a tornado that may only be a mile wide at most. New models are allowing predictions based on smaller polygons. On April 16, 2011 there were 30 tornados in North Carolina. Using the old county based approach would have covered 2,724 square miles with tornado warnings. Using the new polygon approach, only 805 square miles received a warning. Still included uncertainty, but much more contained.

It is important for people to always take action when there is a tornado warning in their area, but this is a big challenge when people see a high chance of a false alarm. The question for people is: "yes, there is always uncertainty, but how much risk are you willing to take?" (especially given the level of damage if the tornado strikes).

Honesty and trust are important, but, sometimes honesty can result in people not taking actions. There is always going to be a "cone of uncertainty" for hurricanes, because you are using models with inherent levels of error. We still have to show the uncertainty and not just our best guess. Also, people react negatively to buzz words, which now include "climate", "environmental", and "government", so communications strategies have to recognize this and work around it. People are concerned that they are not just being warned, but rather that agencies are trying take control of their lives.

There is a shared responsibility for communication as communication is a two-way street. We must continually strive for better communication; trying to understand what people's needs are and how they can best meet those needs. The user always has a responsibility to understand the information they have been given.

Question & Answer

Has anyone approached you about reporting on prescribed fires?

> Short answer, no.

If we wanted to inform you of prescribed fires, who would we contact?

> We can build a relationship. When people don't perceive an immediate threat, they delay taking action. Very open to setting up a communication scheme to get these messages out.

At what point do we have the responsibility to go beyond reporting the science and tell people what to do, what would be best for them to do to protect themselves? Persuading people may require going beyond simply communicating the science.

> I don't believe in climate change; I accept it based on the evidence.

Day 2 Breakout Groups

9:45 am

The organizing team asked the breakout groups to focus on identification of potential research questions and technological advancements needed within each research focal area, considering the draft problem statements for the focal areas that were based on the Day 1 breakout sessions. We do not summarize those discussions here, but suggested changes to the draft problem statements were incorporated into the problem statements provided in the previous section (Day 1 Output – Final Problem Statements).

Breakout Group 1: SmokeReady App

During the SmokeReady App breakout group, Dr. Rappold presented study design and study plans for the Smoke Ready study. EPA researchers have designed the study to quantify health impacts and examine the ability of environmental models to provide timely information on when and where hazardous wildfire smoke conditions are likely to be present and how individuals respond to that information. To meet the study objectives, this research effort will adopt principles of citizen science and leverage mobile technology (phone app) to enhance large scale interactions and enable inputs from the affected populations. Along with the study design, participants discussed diagrams of the app, its design, and outreach opportunities.

During the discussion, participants expressed support for a number of actions that can increase participation including:

- Upfront display of the study goals and role of participant in enhancing understanding about smoke impacts on communities.
- Weekly notifications will improve completeness in the data particularly during periods with no smoke.
- Follow up after periods of no response.
- Real time feedback on the usage statistics and participation rates.
- Media grabbing and information sharing.
- Including learning games about the ways smoke impacts health and ways to protect health.
- Providing the context for air pollution concentrations as relative to recent days.

Break out group discussions also explored opportunities to utilize partnerships to promote participation. For which, development of a communication plan is necessary. Examples of partnership could include partnership with communities, EPA regional offices, American Lung Association, existing AirNow users, wildfire, health or community blogs, Red Cross, Interagency Fire program, and the NIEHS worker training program. Existing partnerships could be used for beta testing and focus group testing prior to the beginning of the study. Additional outreach opportunities could be found at the Annual Conference of Citizen Science Association, May 2017 and the International Smoke Symposium 2, November 2016.

Participants generally thought that the process of app download is not a serious barrier if smoke is of concern. Participants were interested in inter-operability of the app with other apps and technologies such as health devices.

Breakout Group 2: Assessment of Risks from Wildfire Smoke

The current approach to risk communication during fires is based on the AQI, which is single pollutant driven. Consideration should be given to additional tools for risk communication. Finer spatial resolution of information would be needed, as well as new monitoring technologies that can address limitations caused by high concentrations that interfere with measurements. How do we design monitoring networks that better capture wildfire smoke?

We need new tools to integrate large amounts of smoke data and make it useable for risk communication and management purposes. We need methods to enable Air Resource Advisors to communicate risks to both firefighters and health communicators. Improved modeling could help with this by integrating data in a meaningful way for communication to the public.

We need to assess health impacts of mixtures rather than single pollutants, because smoke impacts multiple pollutants, and the risks can be very different depending on which types of fuels are burned. We need better understanding of the impacts of new vs aged smoke. Also need a method to definitively apportion the amount of PM coming from smoke in the air monitoring network. Need risk assessments to understand the health benefits of implementing AQ programs

to reduce smoke exposures, especially in vulnerable communities such as on tribal lands. Tribal programs also need better air monitoring and access to better communication materials to reach tribes. Research is needed on whether low SES communities are more susceptible to smoke exposures or less able to reduce risks due to less access to resources.

Need to assess which groups lack access to risk communications, both before and during smoke events (given that smoke can cut off certain types of communication routes, e.g. lost satellite access). Research is needed into the effectiveness of certain types of risk communication strategies, for example, use of risk context messages such as "risk today is 500 times worse than a typical Los Angeles day of air pollution."

A research design could be to build cohorts in communities that are routinely exposed to wildfire smoke and follow for 10 years. This would meet a major gap in the research on smoke health effects. Would need to account for both acute and chronic effects, and take into account the impacts of SES on access to hospitals and emergency rooms. This could be coupled with analysis of existing health surveillance data that is already available on communities.

Key points:

- How do we validate a deployable monitoring system and how to measure components of smoke?
- What is the nature of exposure and effects for both near-field and far-field smoke exposure? How do we disentangle the effects of other pollutants (source apportionment)?
- How do we lower risk in at-risk communities? What blanket strategies may not work in low SES communities?

Breakout Group 3: Government agency interventions to mitigate exposures and health effects

Research is needed to inform community and individuals decisions, for example, the general public and schools often make decisions based on the AQI, but these values are based on air quality forecasts for a 24-hour time period. How can sub-daily exposure information be incorporated into the information considered? Communities trying to plan for outdoor activities want to know when during a day air quality might be acceptable even when a 24-hour forecast is for unhealthy air, e.g. what if air quality is okay in the afternoon, do we have to cancel school sports practices because of a 24-hour forecast?

Research is needed to evaluate if the AQI is really the "right" metric to use. It is familiar to a subset of the general public but also has limitations (e.g., focuses on individual, criteria pollutants, limited time scale, etc.); consider opportunities to look more broadly at potential fire-related exposures and resulting public health impacts. For example, a different warning system tied but not identical to the AQI could be explored. Could evaluate/test an expanded warning system that is specific to fire smoke and the multiple pollutants produced by wildland fire smoke, focusing on whether people are better able to take protective actions.

Research is needed on measuring the effectiveness of actions and messages to improve protection of public health related to wildland fires, for both community and individual level decisions. We also need to determine the contribution of government interventions and coordination to the effectiveness of the actions. We need to develop metrics to evaluate three components: message sent, message received, message acted on.

In designing evaluations of the effectiveness of interventions, we need to consider the accuracy of available information. For example, if communities are evacuated, how many people go to shelters and how do we take in to consideration others that go to hotels, family/friends' houses, etc. Also need to evaluate the reasons why people may not take protective actions. For example, in the case of evacuation, may need to consider factors such as health problems, financial limitation, inability to get to shelters, etc.

Evaluation of data that informs evacuation decisions (from fires or other natural disasters such as hurricanes) can help to develop more effective messaging.

Research into effectiveness of currently available protective actions could be very valuable in crafting messages. For example, a simple pre-event action to recommend could include having extra HEPA filters available and changing them frequently during a fire episode to have at least one clean room. Evaluation of recent major fires and smoke episodes could help identify approaches that were more or less successful in preventing smoke exposures and health impacts. How does level and duration of smoke affect protection options and recommended approaches to protection?

Breakout Group 4: Message content and delivery

Message content and delivery can be improved, but researchers need to recognize what already exists, and the need to more effectively interact with key stakeholders to enhance the effectiveness of existing approaches.

Evaluation of messages that are appropriate for different scales of audiences is needed, e.g. what messages could be developed that appropriate for all audiences, and how can those be complemented by more targeted messages to different types of vulnerable populations. Are there broad messages providing "rules of thumb" for responding to wildfire smoke that can effectively motivate populations to take protective actions? What are effective ways to include under-served communities in the crafting, delivery and evaluation of risk messages? How do we engage these communities in designing and implementing research in these areas? How do we measure whether effective engagement is occurring?

Research is needed to better understand the types and prevalence of barriers to communicating with at-risk populations. These types of barriers could include knowledge gaps, attitudes and experiences, resource limitations, or other constraints, such as not wanting to leave a pet behind, or having mobility constraints due to a disability. Survey research or focus groups can be

valuable tools to understand how messages are received and interpreted by communities and how they are able to respond to those messages. Research is also needed to understand communities where existing risk messages have been effective, to develop better models of effective risk communication. Case studies can be an effective way to develop these models. Careful consideration of the factors that can affect transferability of results from case studies to more general models will need to be incorporated into research designs. Identification of protective behaviors that can easily be implemented in multiple places is key.

Research should be designed to evaluate the effectiveness of messages that are based on short-term health risks compared to longer-term health risks. A hypothesis might be that messages that focus on short-term health risks, e.g. respiratory symptoms, can elicit behavioral responses more effectively than messages that focus on longer-term risks.

Research is also needed to understand the ethical implications of manipulating and targeting messages to different audiences to achieve behavioral changes. Ethicists and philosophers would need to collaborate with air quality and risk communication experts to understand the implications of driving a population towards a desired goal of improved health using potentially manipulative messages, e.g. emotion based vs fact based.

Better understanding of existing and upcoming technologies to fill gaps in spatial and temporal knowledge during wildfires can help to identify ways to craft more complete and timely messages. Important for air quality modelers to work with visualization experts to communicate the information in a useable way to targeted populations. Research is also needed into how more immediate, continuous air quality information during smoke events can complement the information contained in the AQI forecast.

Better understanding is also needed of how different communities view sources of information during smoke events. What approaches can be used to increase understanding of how trust is established? How do people differentiate between sources of information that are high quality, accredited, and reliable, vs those who are loud and persistent, but not accurate (e.g. some social media sources, some traditional media personalities). What types of standards could be established to provide the public with a way to differentiate amongst sources?

How do we better understand community and individual decision making about smoke exposures and risks in the context of the full range of other risks and challenges faced by those communities? How do we develop decision support tools that allow communities flexibility in addressing these risks? Are different types of message content and delivery needed to reach different levels of organization, e.g. one message for a community leader, a different message for health care providers, and a third message for individuals?

How do better understand how the source of a fire affects trust and willingness to engage in protective behaviors? If there are prescribed fires, will communities be willing to engage in protective behaviors if they believe that the government is responsible for the risk?

Lists of Research and Technology Directions

Following the day 2 breakout sessions, the workshop team summarized the results of those breakout sessions into a list of potential directions for research and technology development. This list is provided below for the three discussion areas, Message Content and Delivery Mechanisms, Government Agency Interventions, and Assessment of Risk from Exposure to Wildfire Smoke:

Improving Air Quality Awareness: Message Content and Delivery Mechanisms

- Assess existing opportunities: what is already available?
- Identify messages that can be used for broad audiences
- Identify groups and individuals that already model behaviors
- Identify the exposure reducing/health protective behaviors that are most effective and that we can recommend that individuals/communities adopt
- Apply research from anthropology, sociology, and psychology to better represent the voices of underserved populations in the development and delivery of messages
- Identify barriers (knowledge, attitudes, resources) to protective action, using research from communications science
- Evaluate message effectiveness through focus groups/surveys and using a community based study
- Identify protective behaviors that are similar or can easily be transferred
- Comparisons of incremental messaging to more radical approaches
- Application of interdisciplinary (epidemiology, communications, and anthropology) approaches to identify connections between minor symptoms/short term effects and behavior and use those connections to increase protective behaviors?
- Apply insights from philosophy and communication sciences to understand the ethics of messaging for behavior change (tradeoffs, manipulation)
- Using experts from modeling, technology, monitoring, fields, visualization, identify new technologies to test to fill in gaps in information to craft better messages?
- Evaluate the effectiveness of the NowCast in communicating shorter term AQI health information to a community (looking closely at current forecasts)
- Evaluate approaches for establishing trust between educationally trained experts in a field vs. self-declared experts
- Investigate how trust differs between planned/unplanned smoke events and the ways in which differences in trust might influence messaging effectiveness
- Evaluate the importance of wildfire smoke issues in communities that have other potentially more important issues, e.g. poverty, other environmental challenges.
- Identify methods for influencing organizations to protect workers/individuals

- Exploring boundaries of responsibility for smoke related health effects, e.g. role of the individual in reducing exposures vs role of agencies in preventing smoke episodes.
- Development of tools/forums for community engagement in crafting messages.
- Assessment of existing tools, metrics, and process measures (e.g. clear communication index) for evaluating the effectiveness of risk communication, using experts from health education, community health, and communications

Government Agency Interventions

- Improve understanding of what defines an effective action, building from examples from the USFS, and catalog effective messages and interventions as well as what makes them effective, including examples of agency cooperation and protective actions.
- Evaluate additional metrics to complement the AQI for the purposes of addressing smoke risk, including shorter term forecasts, multipollutant metrics, smoke specific metrics, evaluating the role of additional monitoring
- Evaluate approaches for measuring public health protection as it relates to agency interventions, including going beyond just measuring delivery of risk messages, e.g. measure how messages are sent, received, and understood, and whether people act in response to messages
- Evaluate the utility of available metrics for measuring impacts
- Evaluate the triggers for various interventions (e.g. pulling responders back), and the ways that risk messages should be adapted to different types of interventions.
- Develop and evaluate metrics for infrastructure interventions, e.g. building characteristics
- Evaluate specific interventions including face masks and clean air shelters.
- Evaluate how the level and duration of smoke affects protection and approaches to providing protection
- Evaluation of bad outcomes, e.g. what went wrong and why? What were the triggers? Weather? Topography?

Assessment of Risk from Exposure to Wildfire Smoke

- Evaluation of designs of monitoring networks to better capture wildfire smoke emissions, and tools to make monitoring data usable and available to different stakeholders
- Development of fine spatial and temporal resolution models of smoke and air quality.
- Development and evaluation of methods for integrating models and monitoring
- Continue studies of the health impacts of smoke, including both acute and chronic exposures, with a focus on multipollutant effects, smoke composition, impact of source fuels, e.g. buildings, and near-field vs far-field exposures. Develop a cohort study of the effects of acute and chronic exposures to smoke

- Evaluation of the contribution of smoke to overall PM exposures
- Assessment of interventions to lower risk of smoke exposures in tribal communities
- Assessment of the accessibility of recommended interventions in different populations
- Assessment of the effectiveness of different approaches for using sensor technologies.

Workshop Feedback Summary

To help plan and improve future workshops, participants were asked to provide feedback using a provided questionnaire. The questionnaire solicited feedback on how well the overarching goal of the workshop was met, as well as the elements of the workshop that supported the goal. Participants were asked to provide their level of agreement with general statements made about the goal of the workshop (5=strongly agree; 4=somewhat agree; 3=neutral; 2=somewhat disagree; 1=strongly disagree; NC=no comment) and to the rate the elements of the workshop (5=excellent; 4=very good; 3=good; 2=fair; 1=poor; NC=no comment). Participants were asked to discuss low ratings. Open-ended questions were also asked. A copy of the Feedback Form and a spreadsheet with all responses can be found in [Appendix C].

We received completed questionnaires from 22 participants, out of the 42 active participants, for a response rate of 52% (Figure 10). The goal of the workshop was to identify opportunities for research and technological solutions that will improve health risk communication strategies, increase health protective behaviors, and reduce the public health burden during wildfire smoke episodes. With respect to the goal the percent and number of participants who strongly agreed include:

- Workshop achieved its goal (Q1) - 76% (16/21)[14] of respondents;
- Workshop reflected broad, multidisciplinary participation (Q2) - 91% (20/22) of respondents;
- All voices were heard during the workshop (Q3) - 100% (21/21) of respondents.

With respect to the elements of the workshop, the percent and number of participants rating each element good to excellent include:

- Effectiveness of the mind map (Q4) – 63% (14/22) of respondents;
- Utility and design of SharePoint site (Q5) – 77% (17/22) of respondents;
- Contextual presentations (Q6) – 100% (21/21) of respondents;
- Day 1 breakouts (Q7) – 100% (22/22) of respondents;
- Day 1 report-out and discussion (Q8) – 86% (19/22) of respondents;

[14] If respondent left a question blank, that non-response was removed from the total number of responses for that question (denominator). A response of "No Comment" was counted as a response and left in the denominator.

- Fire talks (Q9) – 90% (20/22) of respondents;
- Demos/poster sessions (Q10) – 81% (18/22) of respondents;
- App presentation (Q11) – 90% (18/20) of respondents;
- Keynote (Q12) – 100% (20/20) of respondents;
- Day 2 breakouts (Q13) – 100% (20/20) of respondents;
- Day 2 report-out and discussion (Q14) – 89% (17/19) of respondents;
- Workshop room and set-up (Q15) – 100% (22/22) of respondents;
- Overall workshop experience (Q16) – 100% (22/22) of respondents.

Responses to open-ended questions and additional written comments can be found in Appendix C.

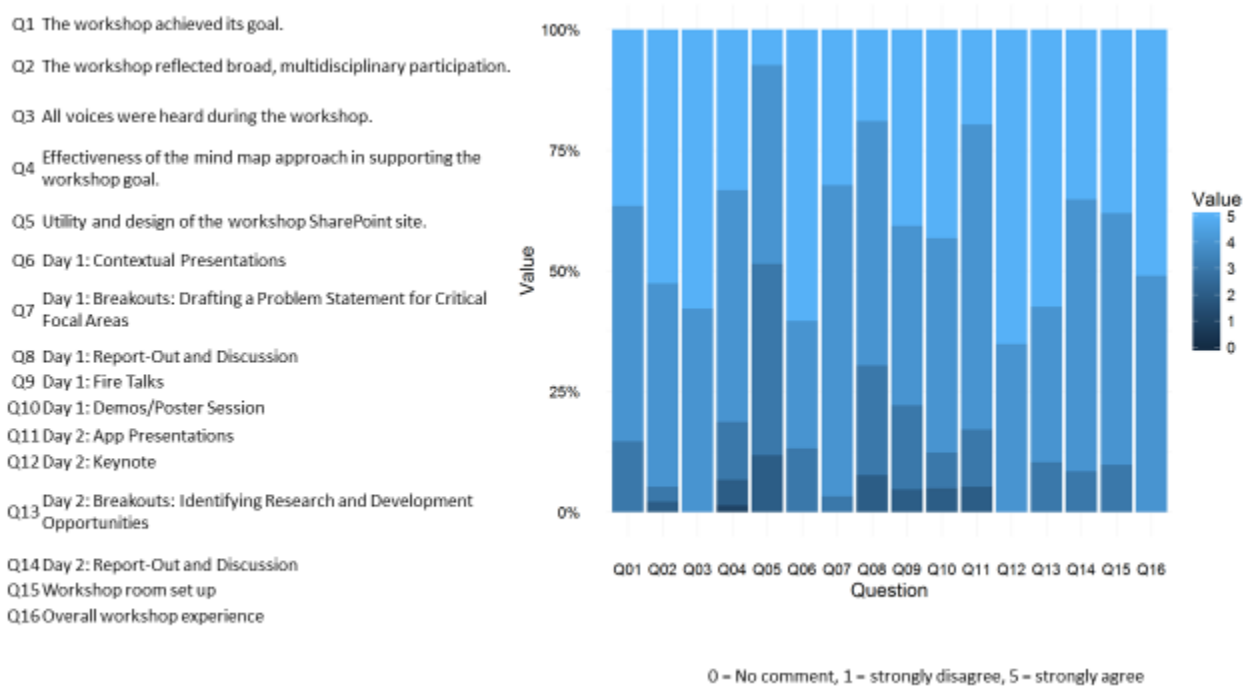


Figure 10: Visual representation of participant feedback, proportion of total responses for each question

Summary and Next Steps

Over the course of the pre-workshop activities and two-day workshop, participants from a variety of backgrounds/disciplines and stakeholder levels: formed a mind-map that conceptualized smoke health risk communication; participated in breakout sessions to create problem statements on the identified focal areas; and participated in breakout sessions to identify research and development opportunities in the knowledge gaps recognized in the focal area problem statements. Participants were generally highly engaged in the workshop processes and enthusiastic about opportunities for future research/collaboration. Many expressed specific

desires to remain in contact with fellow participants, and to be kept updated on workshop reports/results.

Workshop participants identified a number of exciting research opportunities in several areas. Some of the most promising include:

- Application of research from the social and natural sciences towards building trust in impacted communities, e.g. development and delivery of messages for underserved populations
- Identify barriers (knowledge, attitudes, resources) to health protective behaviors and explore new technologies to fill in gaps in information to improve message content and delivery
- Evaluate the use of additional information to complement the AQI during wildfire smoke episodes, e.g., sensors
- Assess effectiveness of interventions – develop metrics for determining who received what messages, actions taken, public health benefit
- Enhance/support monitoring network design to better capture wildfire smoke emissions and enhance the process for disseminating information from the network to individuals/communities/public health officials/first responders
- Develop finer scale models of smoke that advance capabilities to integrate with expanded monitoring data
- Improve our understanding of wildfire smoke specific health impacts, for acute, repeated, and chronic exposures

Following the workshop, the organizers have performed initial follow up by sending the final problem statements and the list of potential research and technology development directions to the workshop participants. This report will also be made available to the workshop participants. Further dissemination is planned through two shorter papers, one on the workshop process, to aid in future social-environmental science collaborations, and one on the workshop results geared toward a public health audience, to advance smoke health risk communication. In addition to the content-specific products of this workshop, the process of workshop planning and integration of social sciences into the EPA's research and communication endeavors is itself a product. Every effort was made during the workshop to encourage well-balanced breakout groups that included multiple disciplinary and stakeholder perspectives. In order to better understand the dynamics of interdisciplinary, multi-stakeholder interactions, we tasked several observers with applying principles of ethnographic analysis to record information on the dynamics of group interactions, including social interactions, individual and group behaviors, the nature of discourse, and the setting in which the discourse occurred. Initial insights from the ethnographic analyses indicate that the personalities within groups can, many times, be one of the strongest factors steering the dynamic of a group. Learned gender roles played a part in the tone of the discussions (degree of involvement, level of agreement vs. disagreement, sitting positions). In addition, the groups who had a large majority of individuals who were already familiar with each other before the conference were able to cooperate much faster than the

groups that did not. These and other insights from the ethnographic analysis provide valuable information for use in designing future interdisciplinary, multi-stakeholder workshops. Outputs from this workshop will provide inputs to EPA scientists to refine and improve future workshops. We view this workshop as a highly successful endeavor in piloting the social-environmental framework developed by EPA.

The Workshop Team

Workshop Organizing Team

Christina Baghdikian –ORD/NHEERL
Kayla Schulte – University of Oxford (formerly with ORD/ACE)
Ken Elstein –ORD/OARS
Bryan Hubbell – OAR/OAQPS
Ana Rappold – ORD/NHEERL
Kristen Rappazzo – ORD/NHEERL
Susan Lyon Stone - OAR/OAQPS

Workshop Facilitators

Beth Hassett-Sipple – ORD/ACE
Gayle Hagler – ORD/NERL
Lisa Baxter – ORD/NERL
Martha Keating – OAR/OAQPS
Elizabeth Corona – ORD/IOAA

Workshop Note-takers

Kate Helmick – ORD/NERL
Bailey Stearns – ORD/CSS
Rosemary Keane – ORD/ACE
Nicole Kim – ORD/ACE
Stephanie Deflorio-Barker – ORD/NHEERL
Ben Zukowski – ORD/CSS

Workshop Observers

Haley Trapp – ORD/NHEERL
Carolyn Hubbard – ORD/IOAA
Melissa McCullough – ORD/SHC
Ann Brown – ORD/ACE
Keely Maxwell – ORD/HS

Directory of Websites Related to Smoke Risk Communication and Management

Incident Information
Inciweb (California) http://inciweb.nwcg.gov/state/5/
CalFire http://cdfdata.fire.ca.gov/incidents/incidents_current

Data Displays
Bluesky smoke plume model runs http://viewer.smoke.airfire.org/
AirNOW wildfire monitoring page https://airnow.gov/index.cfm?action=topics.smoke_wildfires
AirFire monitoring http://smoke.airfire.org/monitoring/#/
AirFire monitoring report http://smoke.airfire.org/monitoringReport/#/

Messaging
AirNow Wildfire Guide https://www3.epa.gov/airnow/wildfire_may2016.pdf
California Smoke Blog http://californiasmokeinfo.blogspot.com/
California Smoke Blog Twitter https://twitter.com/CASmokeBlog
CDC Gateway to Health Communication & Social Marketing Practice
http://www.cdc.gov/healthcommunication/risks/index.html

Air Emergency Response Planning
CARPA website http://www.arb.ca.gov/carpa/carpa.htm

California Wildfire Smoke Response Coordination Guide
https://www.arb.ca.gov/carpa/cawildfiresmokeresponsecoordinationaug14.pdf

References

Fischhoff, Baruch. "Risk perception and communication unplugged: twenty years of process." Risk analysis 15.2 (1995): 137-145.

Liu, J. C., Pereira, G., Uhl, S. A., Bravo, M. A., & Bell, M. L. (2015). A systematic review of the physical health impacts from non-occupational exposure to wildfire smoke. *Environmental research*, *136*, 120-132.

Okada A, Buckingham-Shum S, Sherborne T (eds.). 2008. Knowledge Cartography: Software tools and mapping techniques. Advanced Information and Knowledge Processing, 1. London, UK: Springer.

Rappold, A.G., Reyes, J., Pouliot, G., Cascio, W.E., Diaz-Sanchez D., Community vulnerability to health impacts of wildland fire smoke exposure. In review.

Reid, C. E., Brauer, M., Johnston, F. H., Jerrett, M., Balmes, J. R., & Elliott, C. T. (2016). Critical review of health impacts of wildfire smoke exposure. Environ Health Perspect, 124(9), 1334-43.

Safayeni F, Derbentseva N, Cañas AJ. 2005. A Theoretical Note on Concept Maps and the Need for Cyclic Concept Maps. Journal of Research in Science Teaching, 42(7), 741-766.

Siegrist, Michael, and George Cvetkovich. "Perception of hazards: The role of social trust and knowledge." Risk analysis 20.5 (2000): 713-720.

Shrier I, Platt RW. 2008. Reducing bias through directed acyclic graphs. BMC Medical Research Methodology 2008, 8:70 doi:10.1186/1471-2288-8-70 http://www.biomedcentral.com/1471-2288/8/70

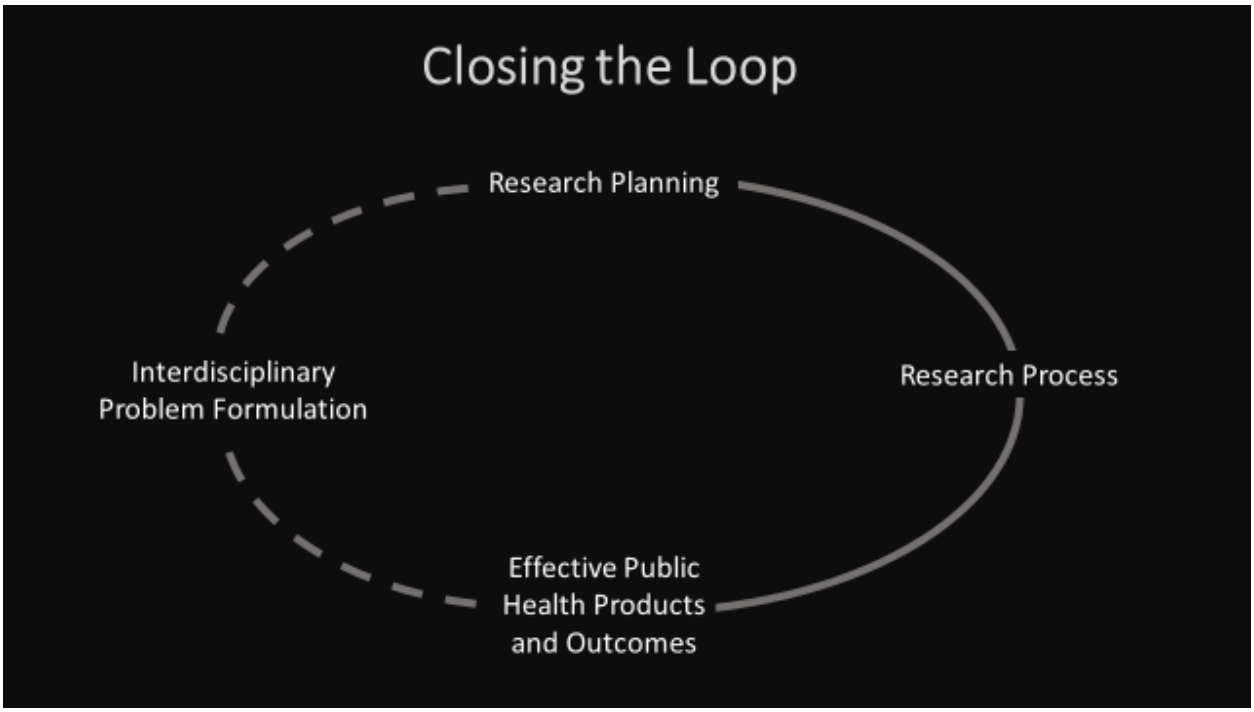
U.S. Environmental Protection Agency. 2014. Climate change indicators in the United States, 2014. Third edition. EPA 430-R-14-004. www.epa.gov/climatechange/indicators

Appendices

Appendix A – Pre-workshop Mind-mapping webinar

Bryan: Motivation 5 characteristics, Participation breakdown
Christina: Workshop process breakdown

Kayla: Instructions for Mind Map
All- Q/A
Kayla: SharePoint
Bryan/Christina: Closing



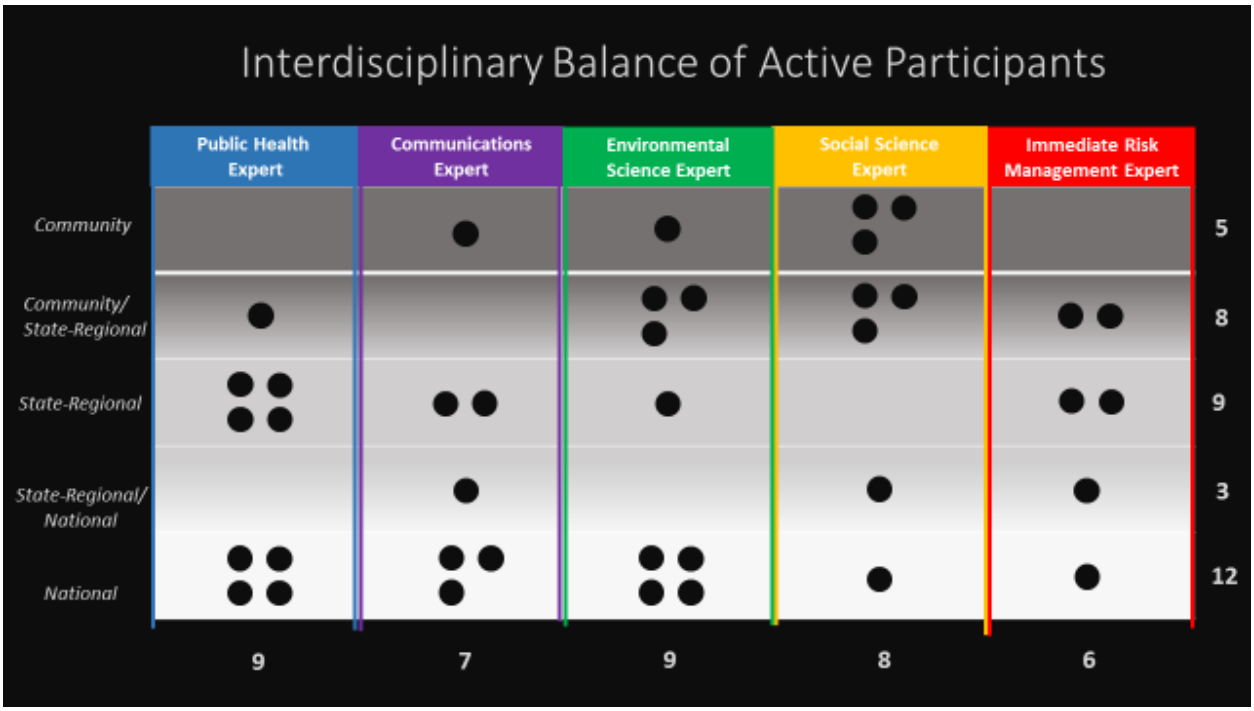
In order to bridge the gap between Research (planning + process) and Effective Public health products & Outcomes, we must engage the experts and stakeholders at the onset by introducing the "Interdisciplinary Problem Formulation" step
This step is crucial for Informing research directions that can lead to actionable results:

- Mobile App - ACE Researcher Ana Rappold is leading the development of an EPA mobile app focused on increasing smoke awareness, preparedness, and response
- Making AirNow as effective as possible at helping communities and individuals reduce their exposures during smoke episodes

The Office of Research and Development's Air Climate and Energy program is committed to supporting effective Public Health Products and Outcomes by integrating social sciences throughout its research process
We've proposed a dynamic, highly interactive Workshop to lay the groundwork for better communication, coordination and leveraging of smoke-related research efforts and knowledge across academic institutions, national-to-local scale government, and impacted communities around the country

1. We want participants to tell us what the problems are, and not us laying out the problem
2. 2. Workshop designed to include the Mind Map exercise to collect the interdisciplinary perspectives around this topic.
3. 2. Participants are engaged and starting to think about what is and isn't working in the context of wildfire smoke: risk management and communication well before September 22 and 23.

2. Utilizing Eventbrite questions and mind maps to prompt meaningful discussion at the workshop.
3. Social and natural scientists from a range of perspectives and disciplines involved in problem formulation
4. Observational activity to see where the workshop process design is working and not working for replication in the future
5. Gathering information at the end of day 2 on what the participants expect in terms of future collaboration, info sharing, and future engagement.



Participant breakdown:

Before your eyes bounce all over at this slide, I want to tell you that this is to show you the diversity of participants we have identified and the different areas of expertise, and areas of engagement you all have. Now, this is an EPA organized event, but we declined some EPA requests in order to make sure we had good representation of non-EPA people while keeping this event small in #'s.

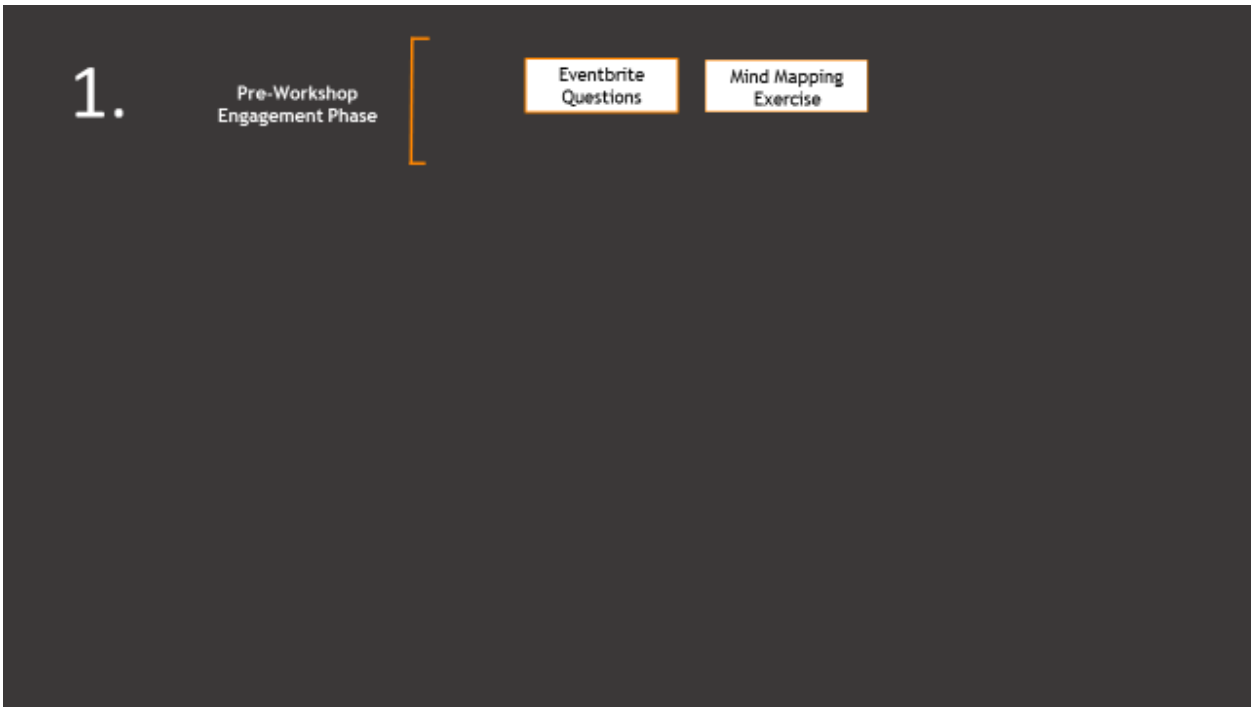
Visualizing the variety of participants, according to their:

1. Area of expertise
2. Area of engagement
3. The participants represent Academic, local/state/fed government agencies, communities, etc.

37 registered participants out of 50 invitees

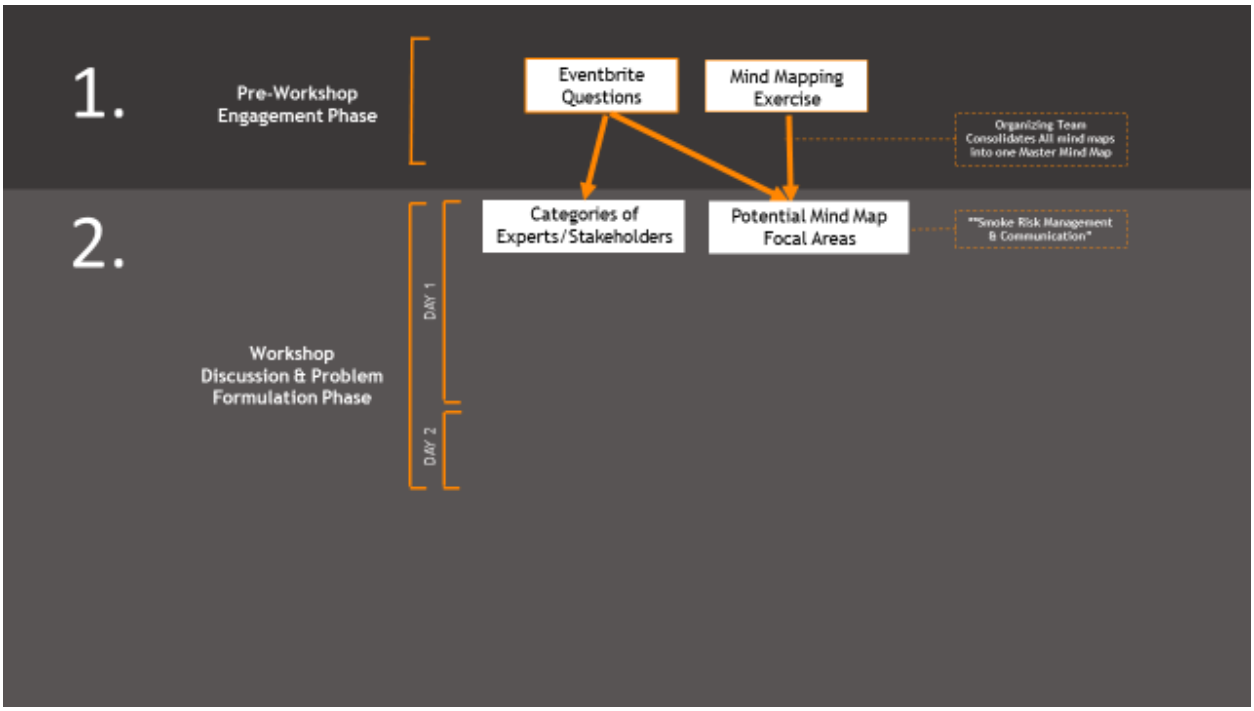
Allows the opportunity for an integration of perspectives

- We're saying it twice! This workshop is different
- Now we will identify key components/activities taking place over the course of the workshop process that are designed to foster each of these 5 characteristic objectives

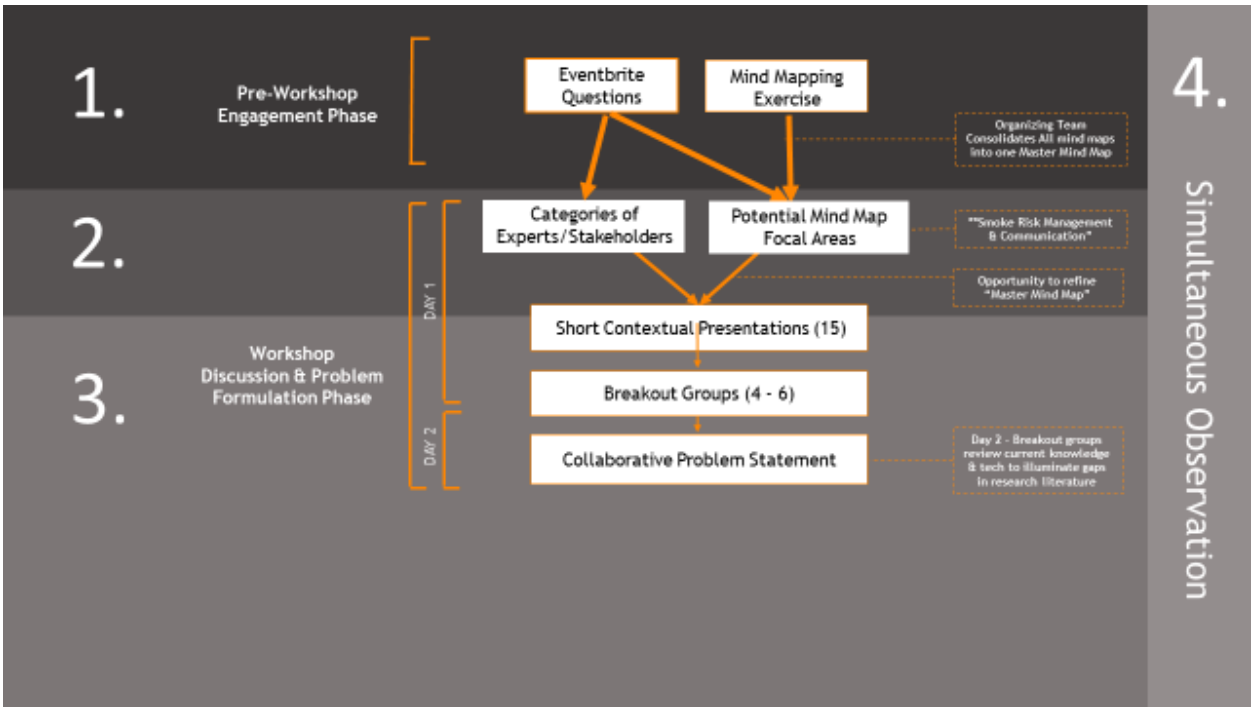


1. Participant-driven – pre-workshop engagement activities are designed to glean perspectives of all active participants
2. This webinar, and these Eventbrite questions are all part of the Pre-workshop engagement phase.

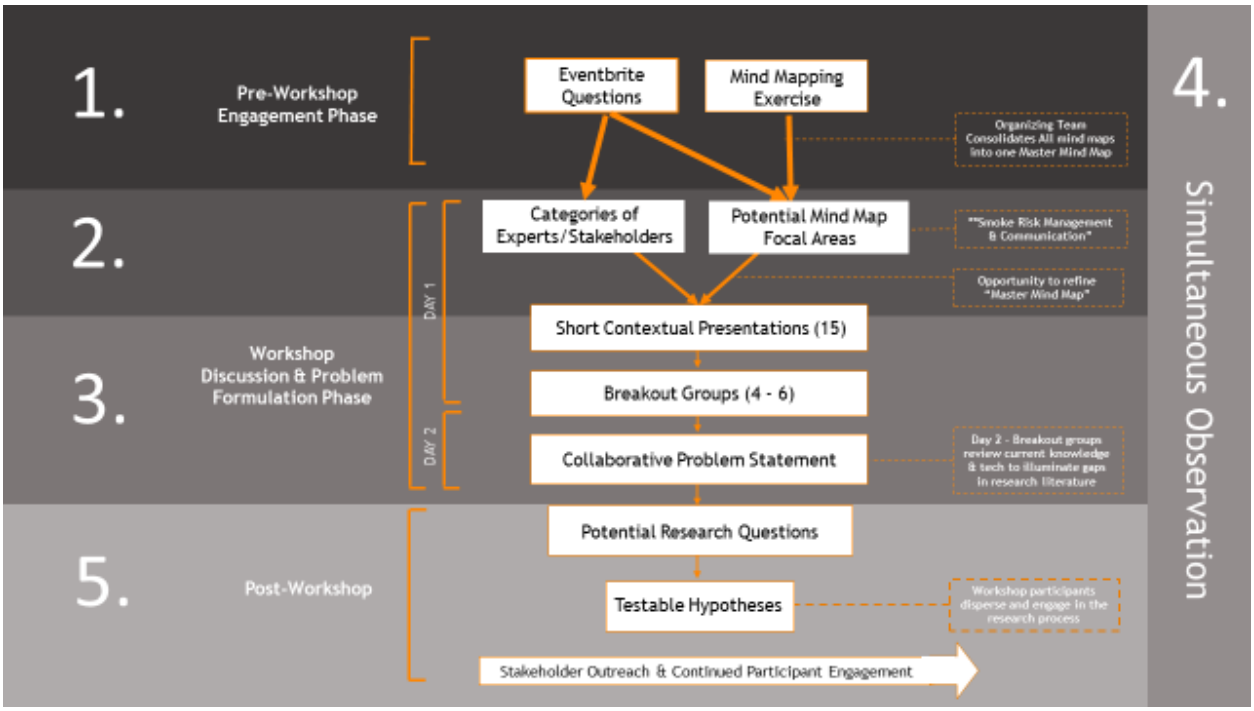
Both of these pre-workshop engagement activities emphasize our #1 characteristic of being participant driven and feed into



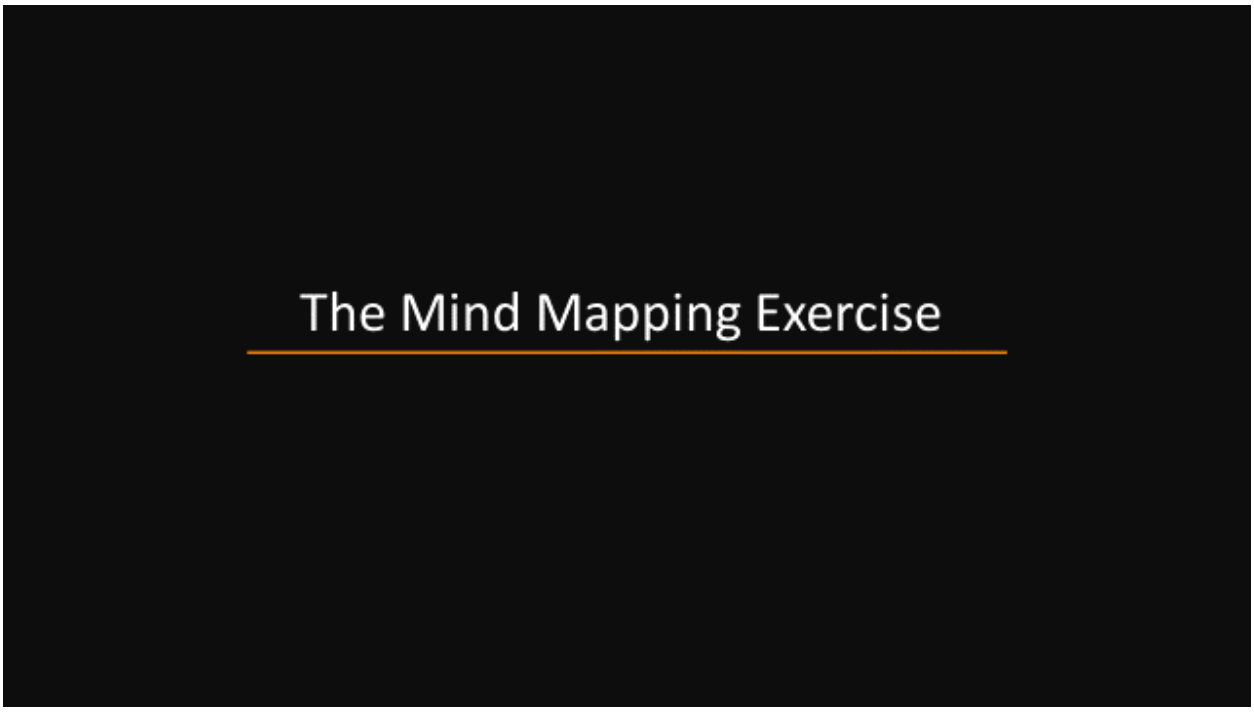
Setting the stage: From that Pre-Workshop Engagement phase, the Organizing Team will utilize perspectives on the Problem (as it's been defined and mapped out by the participants), to inform breakout group composition and foci during the second phase of the Workshop Process – the Workshop Discussion and Problem Formulation Phase

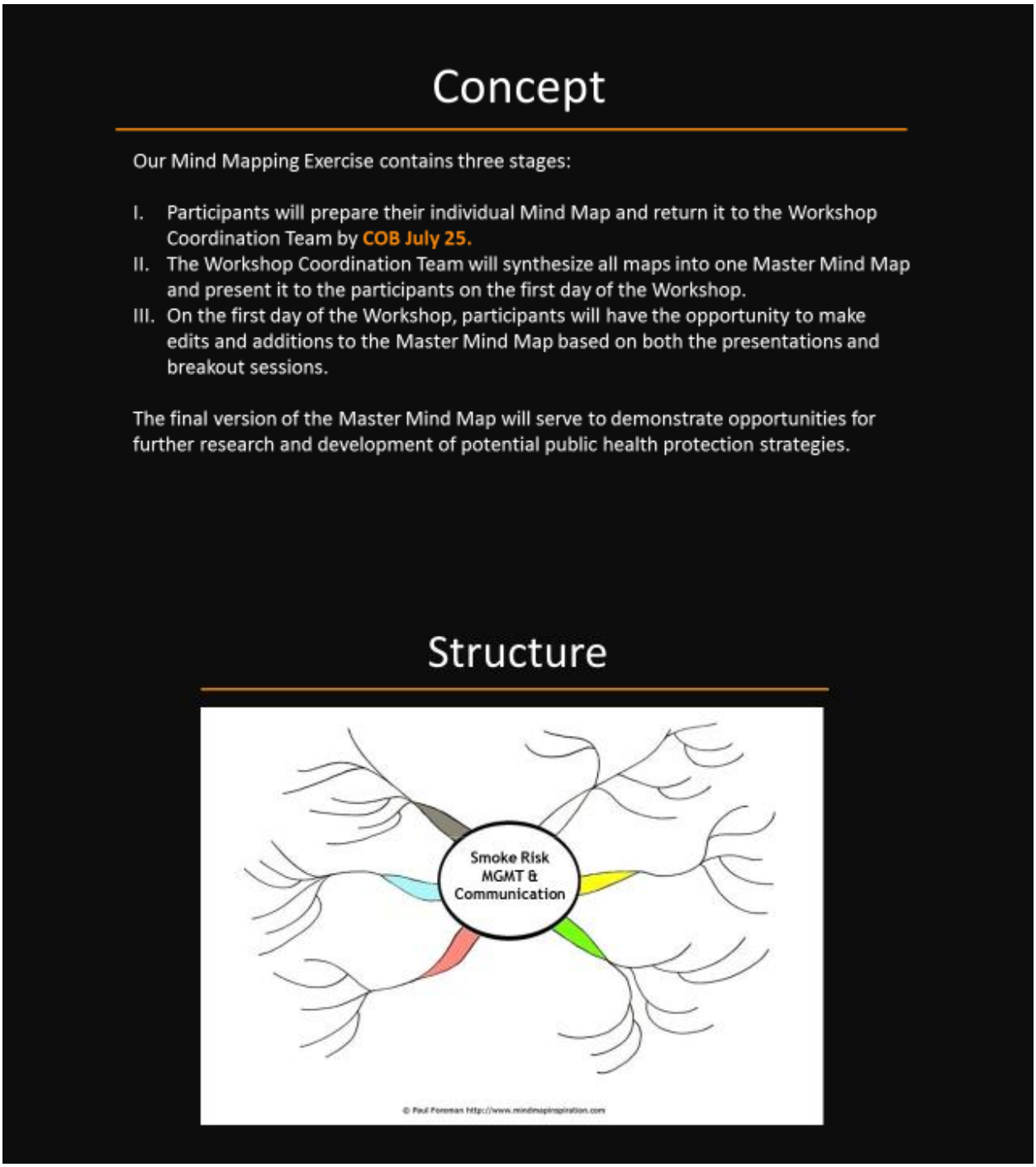


There will be additional opportunities over the course of the two-day workshop for participants to infuse their unique perspectives and expertise into the discussions and workshop outcomes.
Day 2 – Breakout groups review current knowledge & tech to illuminate gaps in research literature
Simultaneous observational component occurs over the course the pre, during and post workshop phases



Collective problem statement(s) emerging from the workshop feed into determining the key science/research questions from which to develop testable hypotheses – facilitating a joint understanding of the problem areas and where to make an impact.

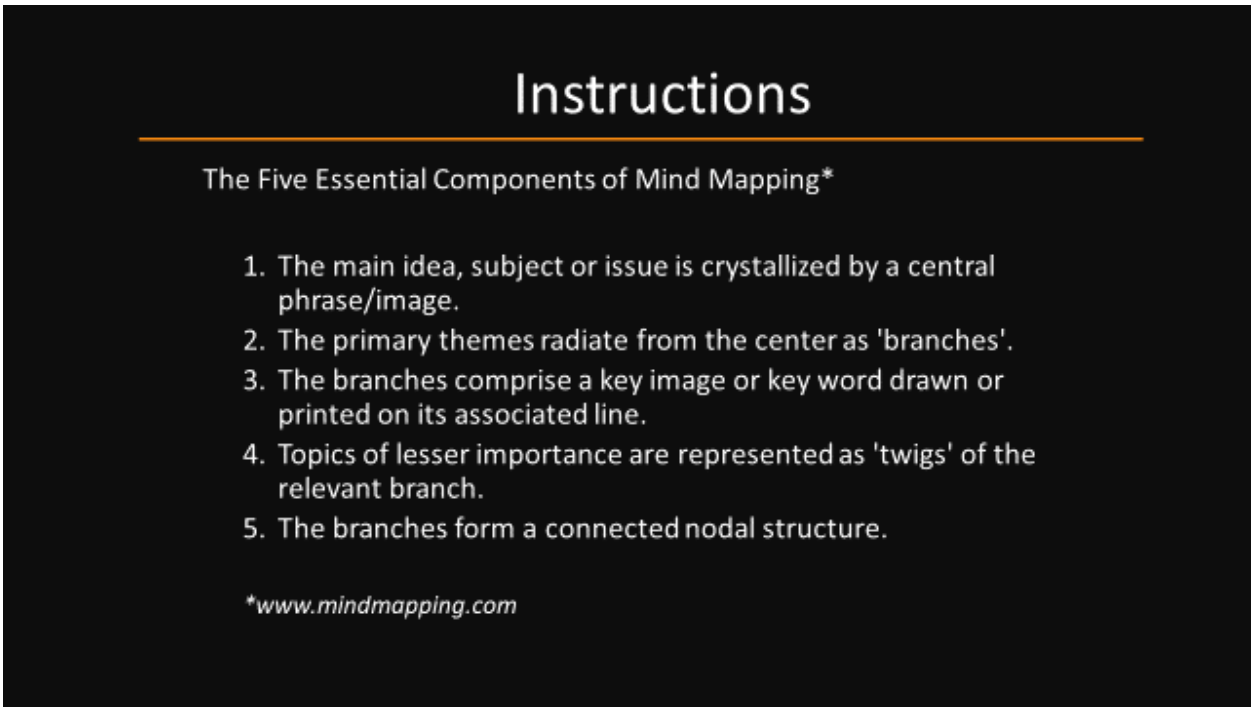


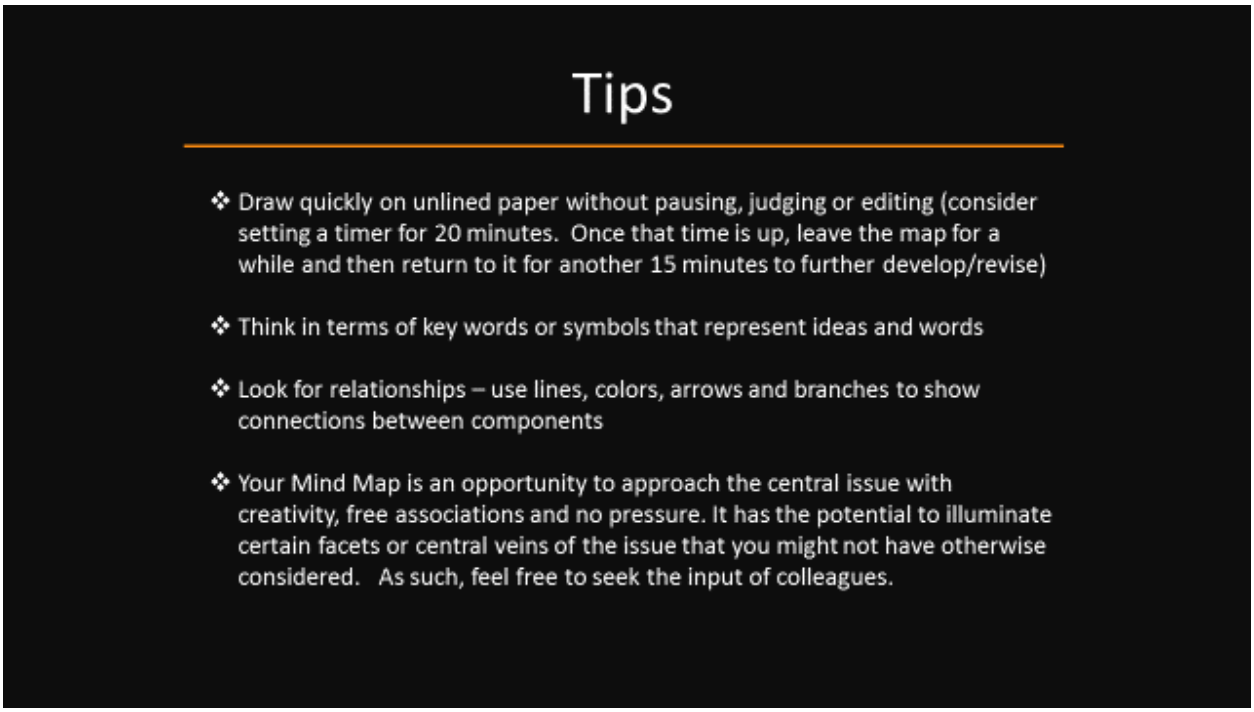


The Five Essential Components of Mind Mapping*

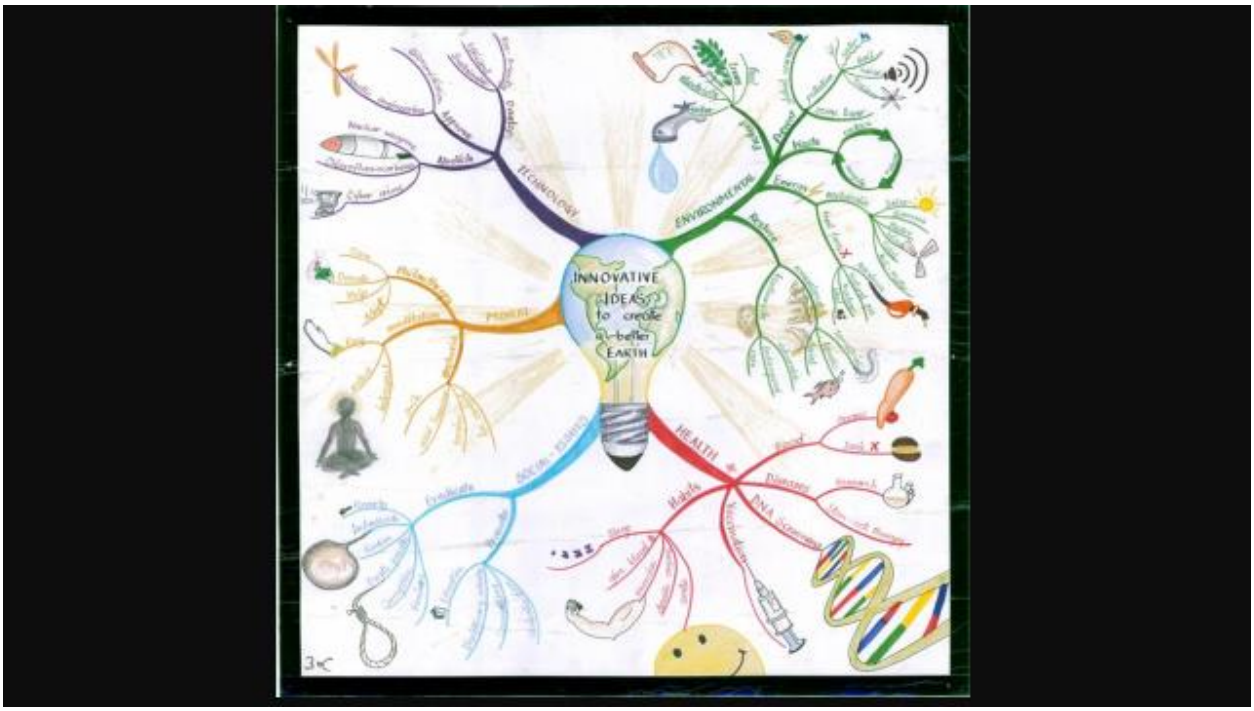
1. The main idea, subject or issue is crystallized by a central phrase/image.
2. The primary themes radiate from the center as 'branches'.
3. The branches comprise a key image or key word drawn or printed on its associated line.
4. Topics of lesser importance are represented as 'twigs' of the relevant branch.
5. The branches form a connected nodal structure.

**www.mindmapping.com*





Purpose of the MIND MAP: *To help us develop a comprehensive definition of the problem, we are using the technique of "Mind Mapping" to compile everyone's perspectives on all of the relevant facets that need to be considered.*



Submit your Mind Map

Complete your individual Mind Map by close of business on JULY 25th 2016.

Your map can be illustrated, scanned and emailed to the Workshop Planning Team or generated digitally using PowerPoint or some other mapping software.

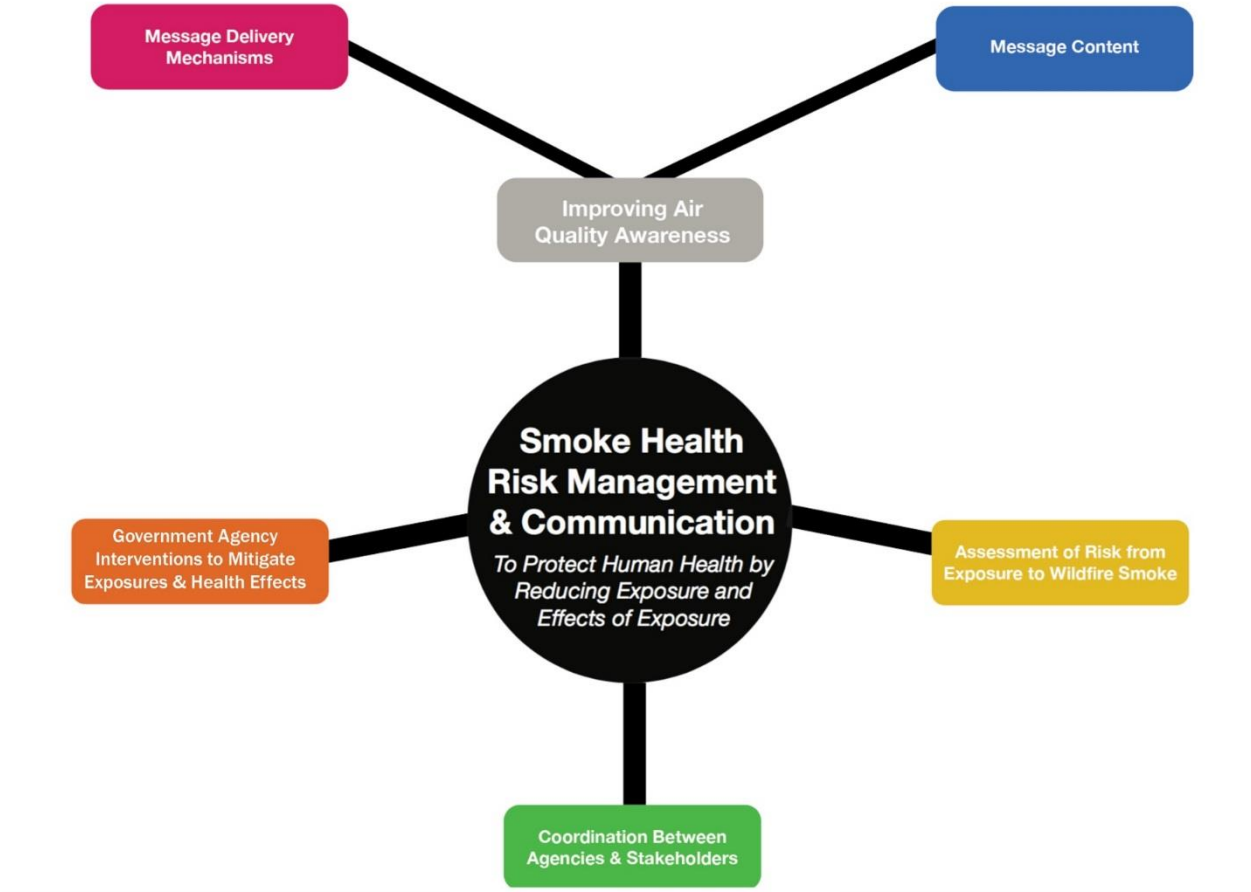
Email your mind map to Kayla Schulte at schulte.kayla@epa.gov

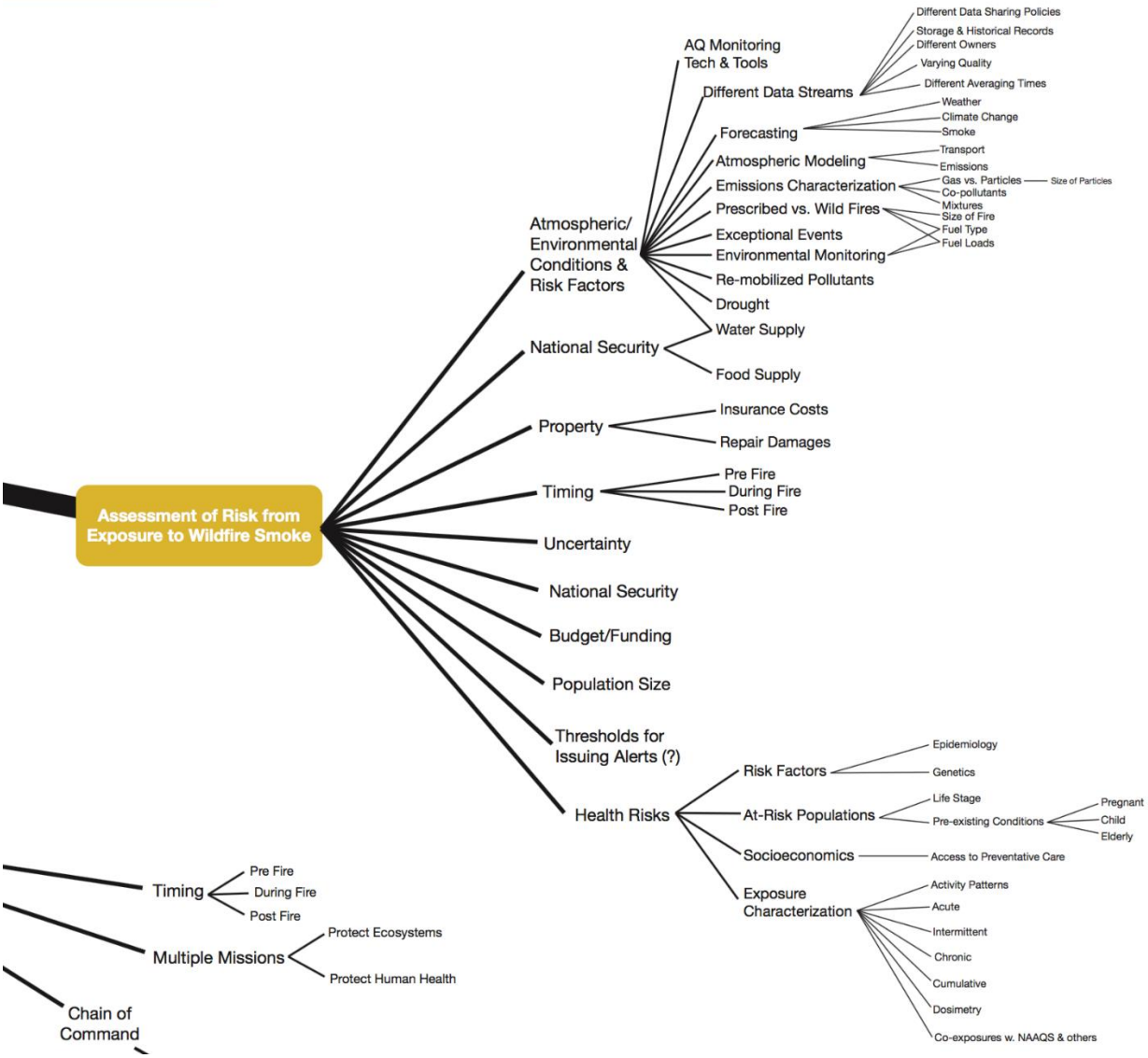
Questions?

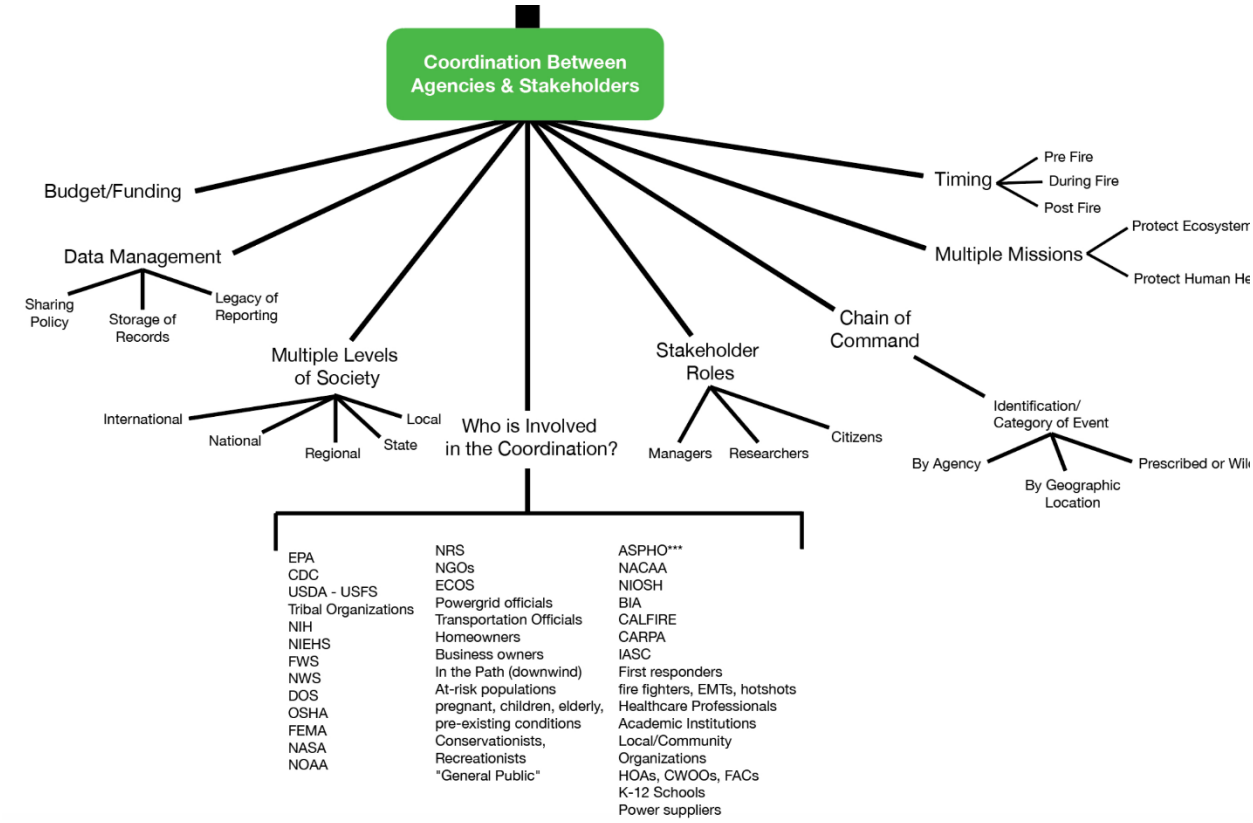
Quick Tour of SharePoint

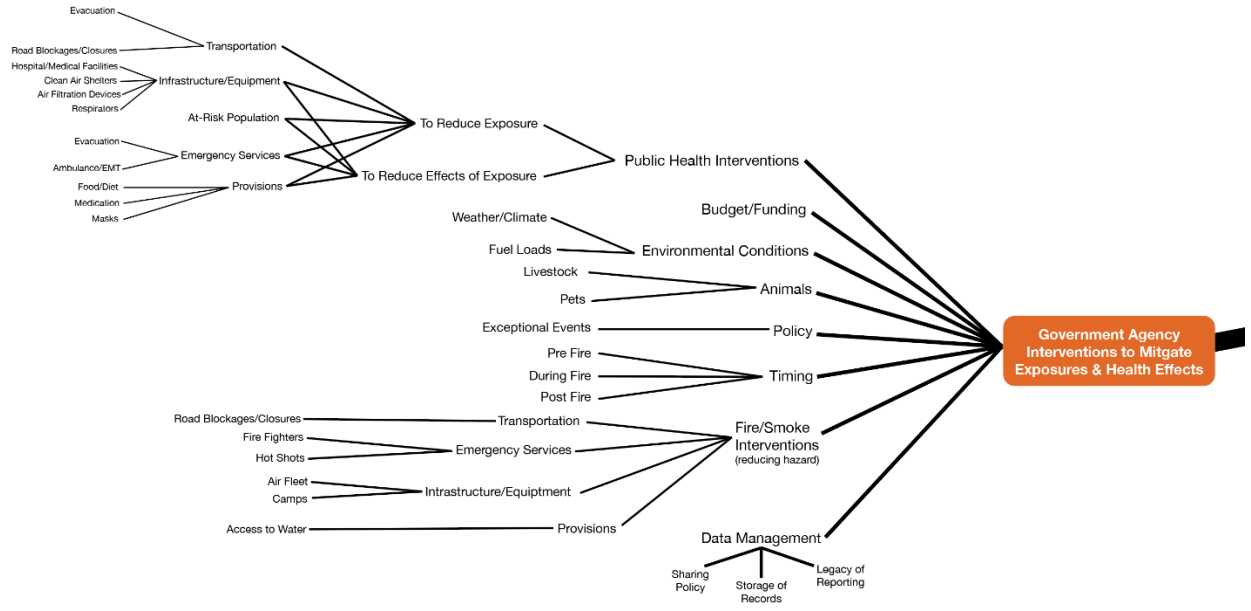
Appendix B – Mind maps

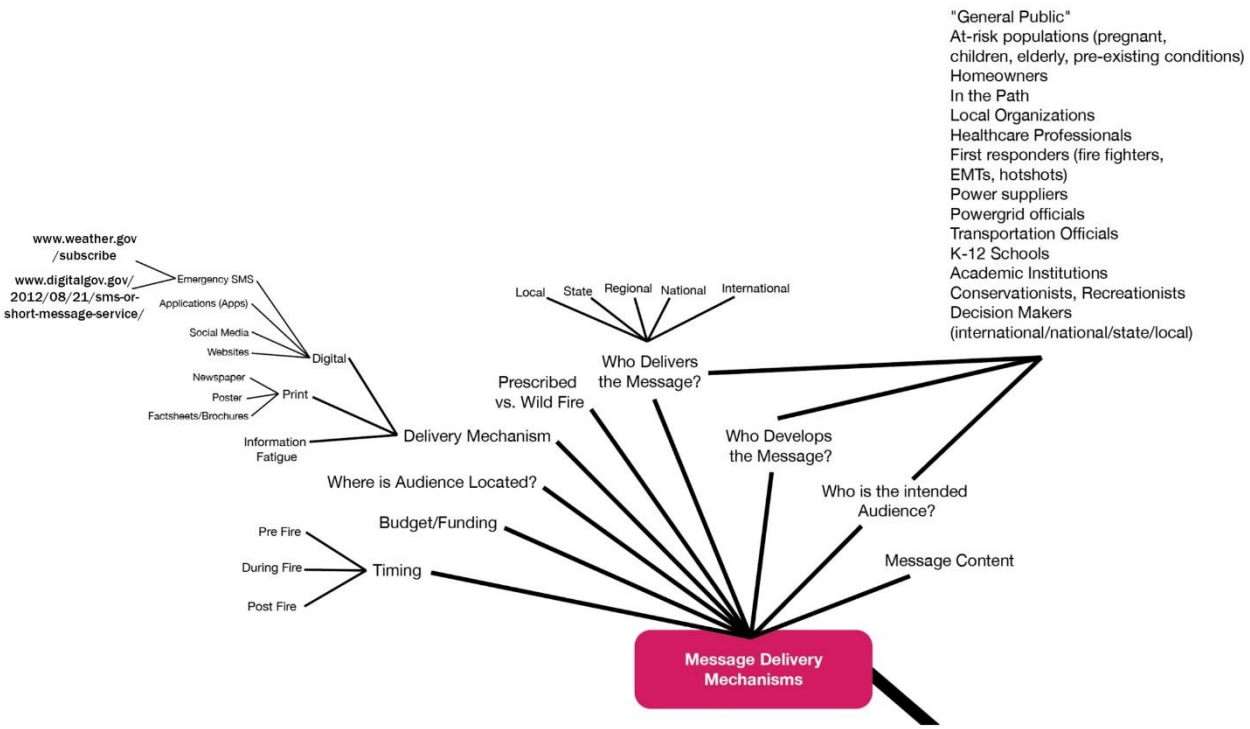
Pre-workshop mind map:



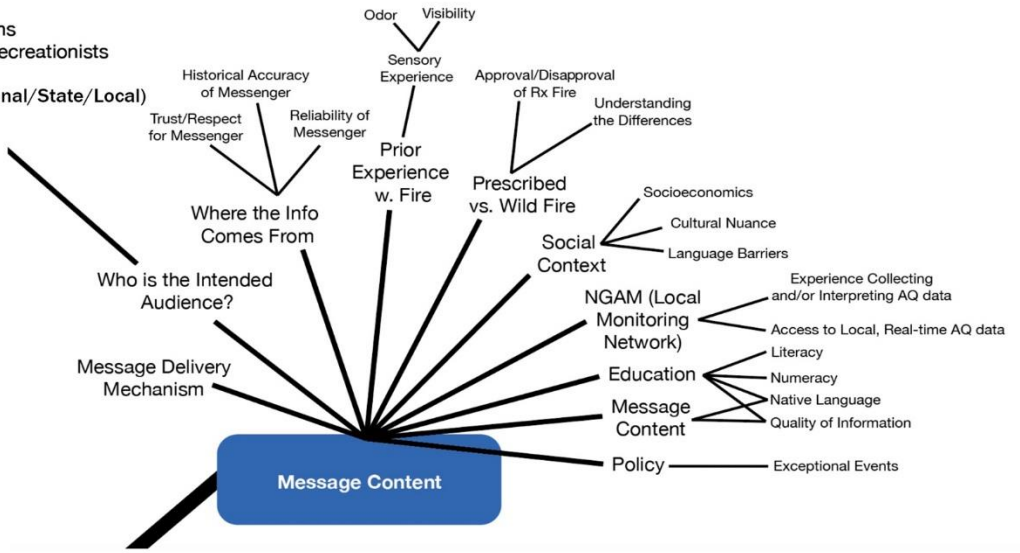

Assessment of Risk from Exposure to Wildfire Smoke
Atmospheric/ Environmental Conditions & Risk Factors
AQ Monitoring Tech & Tools
Different Data Streams
Different Data Sharing Policies
Storage & Historical Records
Different Owners
Varying Quality
Different Averaging Times
Forecasting
Weather
Climate Change
Smoke
Atmospheric Modeling
Transport
Emissions
Emissions Characterization
Gas vs. Particles
Size of Particles
Co-pollutants
Mixtures
Prescribed vs. Wild Fires
Size of Fire
Fuel Type
Fuel Loads
Exceptional Events
Environmental Monitoring
Re-mobilized Pollutants
Drought
Water Supply
National Security
Food Supply
Property
Insurance Costs
Repair Damages
Timing
Pre Fire
During Fire
Post Fire
Uncertainty
National Security
Budget/Funding
Population Size
Thresholds for Issuing Alerts (?)
Health Risks
Risk Factors
Epidemiology
Genetics
At-Risk Populations
Life Stage
Pre-existing Conditions
Pregnant
Child
Elderly
Socioeconomics
Access to Preventative Care
Exposure Characterization
Activity Patterns
Acute
Intermittent
Chronic
Cumulative
Dosimetry
Co-exposures w. NAAQS & others
Timing
Pre Fire
During Fire
Post Fire
Multiple Missions
Protect Ecosystems
Protect Human Health
Chain of Command


Coordination Between Agencies & Stakeholders
Budget/Funding
Data Management
Sharing Policy
Storage of Records
Legacy of Reporting
Multiple Levels of Society
International
National
Regional
State
Local
Who is Involved in the Coordination?
Stakeholder Roles
Managers
Researchers
Citizens
Chain of Command
Identification/ Category of Event
By Agency
By Geographic Location
Prescribed or Wil
Timing
Pre Fire
During Fire
Post Fire
Multiple Missions
Protect Ecosystem
Protect Human He
EPA
CDC
USDA - USFS
Tribal Organizations
NIH
NIEHS
FWS
NWS
DOS
OSHA
FEMA
NASA
NOAA
NRS
NGOs
ECOS
Powergrid officials
Transportation Officials
Homeowners
Business owners
In the Path (downwind)
At-risk populations
pregnant, children, elderly, pre-existing conditions
Conservationists, Recreationists
"General Public"
ASPHO***
NACAA
NIOSH
BIA
CALFIRE
CARPA
IASC
First responders
fire fighters, EMTs, hotshots
Healthcare Professionals
Academic Institutions
Local/Community Organizations
HOAs, CWOOs, FACs
K-12 Schools
Power suppliers

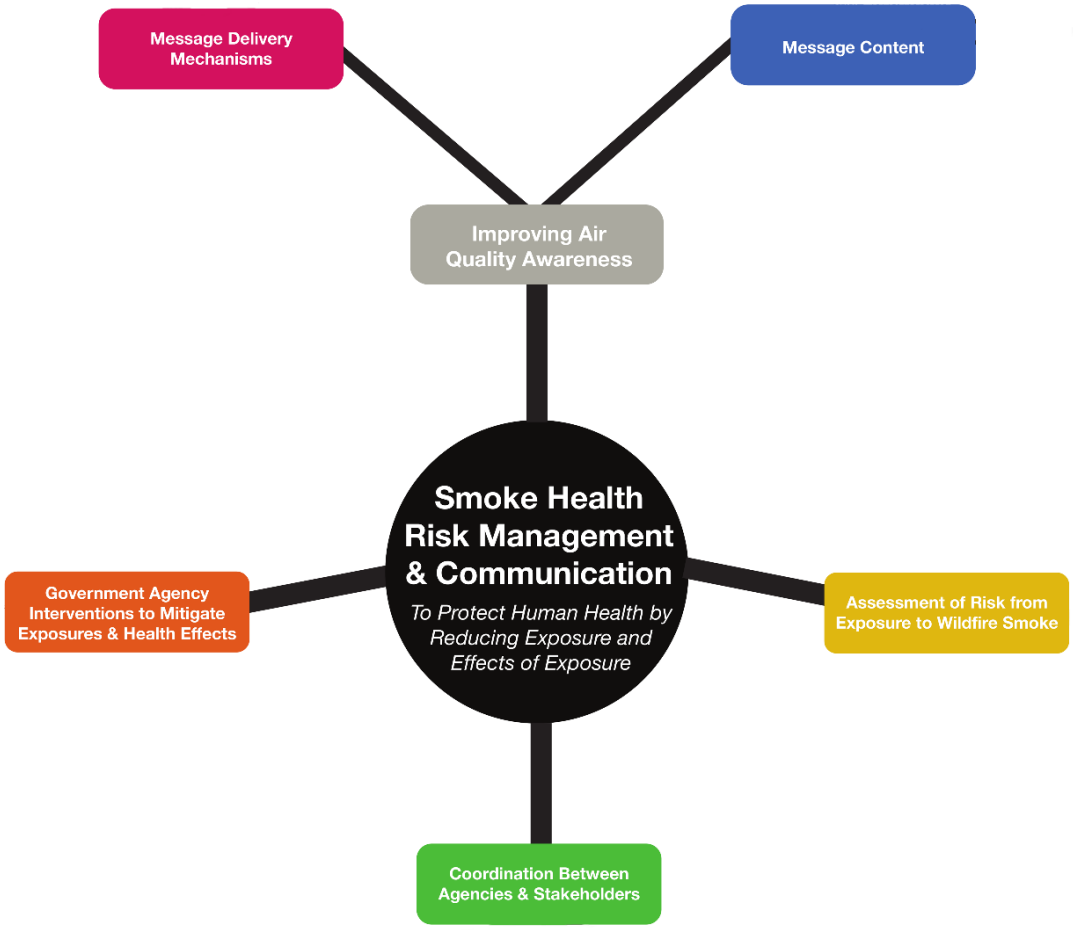

Evacuation
Road Blockages/Closures
Transportation
Hospital/Medical Facilities
Clean Air Shelters
Air Filtration Devices
Respirators
Infrastructure/Equipment
At-Risk Population
Evacuation
Ambulance/EMT
Emergency Services
Food/Diet
Medication
Masks
Provisions
To Reduce Exposure
To Reduce Effects of Exposure
Public Health Interventions
Weather/Climate
Fuel Loads
Environmental Conditions
Livestock
Pets
Animals
Exceptional Events
Policy
Pre Fire
During Fire
Post Fire
Timing
Road Blockages/Closures
Transportation
Fire Fighters
Hot Shots
Emergency Services
Air Fleet
Camps
Intrastructure/Equiptment
Access to Water
Provisions
Fire/Smoke Interventions
(reducing hazard)
Budget/Funding
Data Management
Sharing Policy
Storage of Records
Legacy of Reporting
Government Agency Interventions to Mitgate Exposures & Health Effects

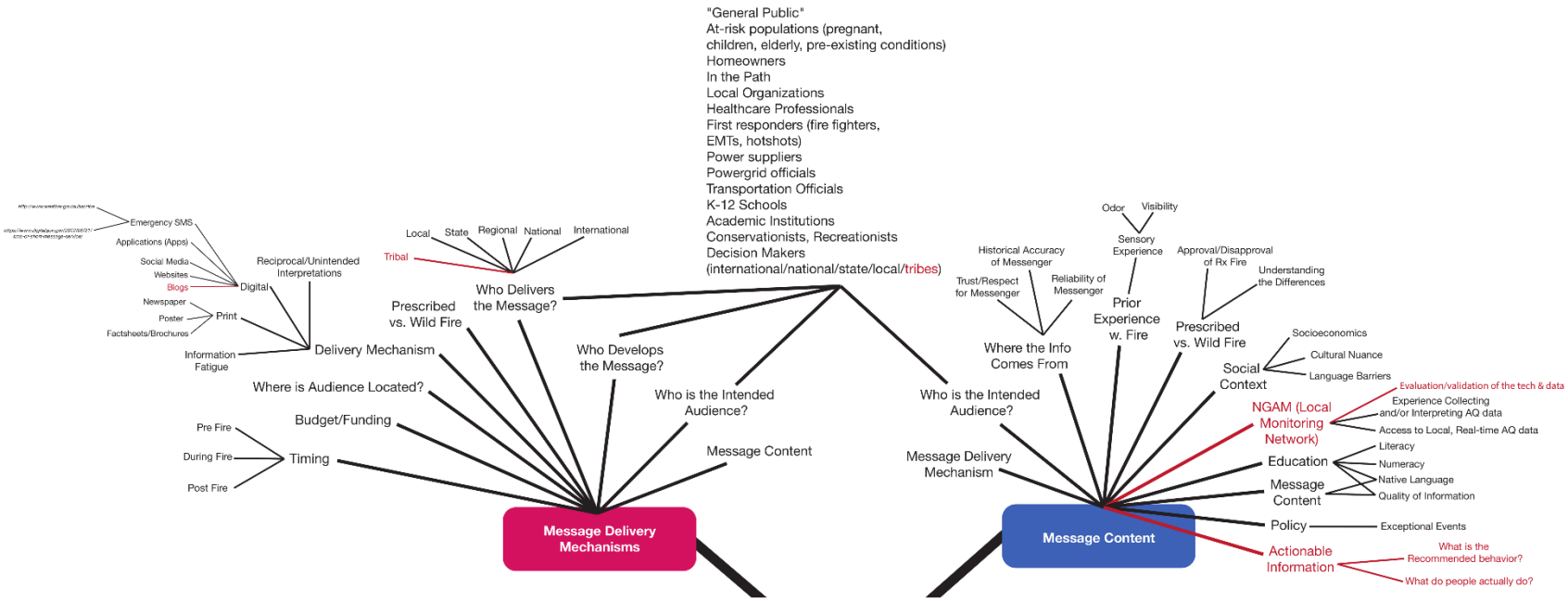

"General Public"
At-risk populations (pregnant, children, elderly, pre-existing conditions)
Homeowners
In the Path
Local Organizations
Healthcare Professionals
First responders (fire fighters, EMTs, hotshots)
Power suppliers
Powergrid officials
Transportation Officials
K-12 Schools
Academic Institutions
Conservationists, Recreationists
Decision Makers
(international/national/state/local)
Local
State
Regional
National
International
Who Delivers the Message?
www.weather.gov/subscribe
www.digitalgov.gov/2012/08/21/sms-or-short-message-service/
Emergency SMS
Applications (Apps)
Social Media
Websites
Digital
Newspaper
Poster
Factsheets/Brochures
Print
Information Fatigue
Delivery Mechanism
Prescribed vs. Wild Fire
Who Develops the Message?
Who is the intended Audience?
Where is Audience Located?
Budget/Funding
Pre Fire
During Fire
Post Fire
Timing
Message Content
Message Delivery Mechanisms

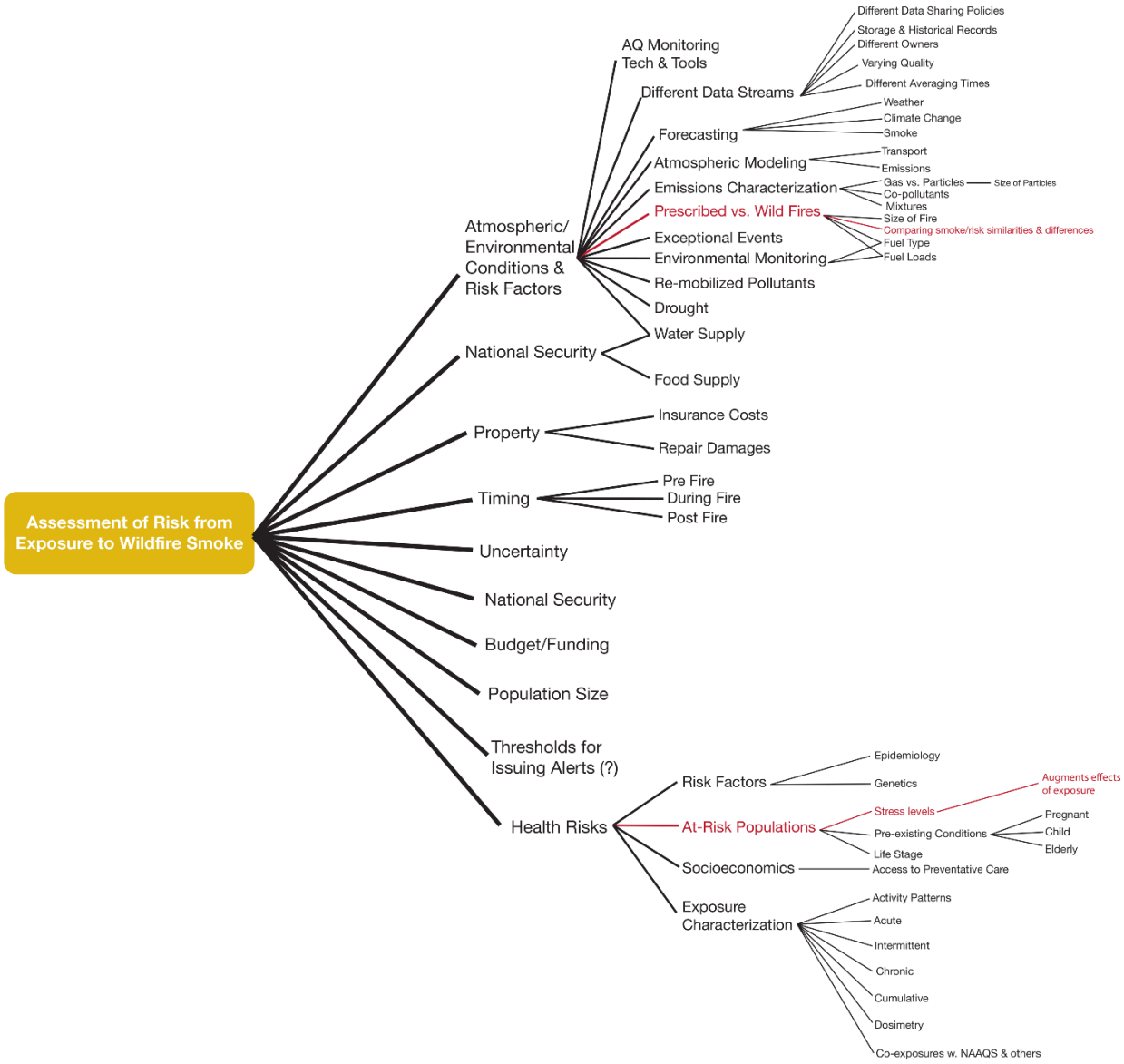
"General Public"
At-risk populations (pregnant, children, elderly, pre-existing conditions)
Homeowners
In the Path
Local Organizations
Healthcare Professionals
First responders (fire fighters, EMTs, hotshots)
Power suppliers
Powergrid officials
Transportation Officials
K-12 Schools
Academic Institutions
Conservationists, Recreationists
Decision Makers
(International/National/State/Local)

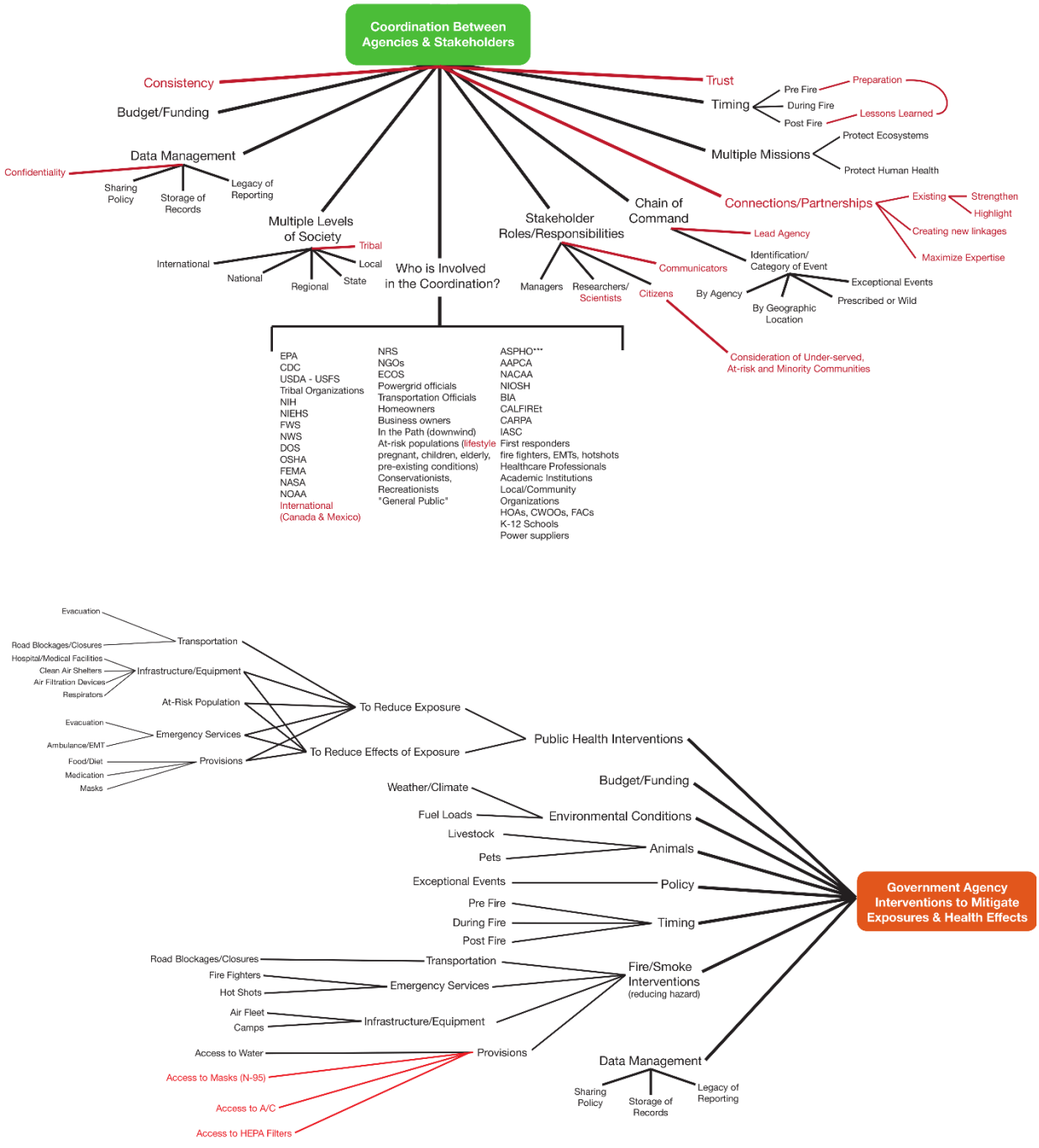


Post-workshop mind map:




"General Public"
At-risk populations (pregnant, children, elderly, pre-existing conditions)
Homeowners
In the Path
Local Organizations
Healthcare Professionals
First responders (fire fighters, EMTs, hotshots)
Power suppliers
Powergrid officials
Transportation Officials
K-12 Schools
Academic Institutions
Conservationists, Recreationists
Decision Makers
(international/national/state/local/tribes)
Who Delivers the Message?
Local
State
Regional
National
International
Tribal
Who Develops the Message?
Who is the Intended Audience?
Message Content
Delivery Mechanism
Emergency SMS
Applications (Apps)
Social Media
Websites
Blogs
Digital
Newspaper
Poster
Factsheets/Brochures
Print
Information Fatigue
Reciprocal/Unintended Interpretations
Prescribed vs. Wild Fire
Where is Audience Located?
Budget/Funding
Timing
Pre Fire
During Fire
Post Fire
Message Delivery Mechanisms
Who is the Intended Audience?
Message Delivery Mechanism
Where the Info Comes From
Historical Accuracy of Messenger
Trust/Respect for Messenger
Reliability of Messenger
Prior Experience w. Fire
Sensory Experience
Odor
Visibility
Prescribed vs. Wild Fire
Approval/Disapproval of Rx Fire
Understanding the Differences
Social Context
Socioeconomics
Cultural Nuance
Language Barriers
NGAM (Local Monitoring Network)
Evaluation/validation of the tech & data
Experience Collecting and/or Interpreting AQ data
Access to Local, Real-time AQ data
Education
Literacy
Numeracy
Native Language
Message Content
Quality of Information
Policy
Exceptional Events
Actionable Information
What is the Recommended behavior?
What do people actually do?
Message Content


Assessment of Risk from Exposure to Wildfire Smoke
Atmospheric/ Environmental Conditions & Risk Factors
AQ Monitoring Tech & Tools
Different Data Streams
Different Data Sharing Policies
Storage & Historical Records
Different Owners
Varying Quality
Different Averaging Times
Forecasting
Weather
Climate Change
Smoke
Atmospheric Modeling
Transport
Emissions
Emissions Characterization
Gas vs. Particles
Size of Particles
Co-pollutants
Mixtures
Prescribed vs. Wild Fires
Size of Fire
Comparing smoke/risk similarities & differences
Fuel Type
Fuel Loads
Exceptional Events
Environmental Monitoring
Re-mobilized Pollutants
Drought
Water Supply
National Security
Food Supply
Property
Insurance Costs
Repair Damages
Timing
Pre Fire
During Fire
Post Fire
Uncertainty
National Security
Budget/Funding
Population Size
Thresholds for Issuing Alerts (?)
Health Risks
Risk Factors
Epidemiology
Genetics
At-Risk Populations
Augments effects of exposure
Stress levels
Pre-existing Conditions
Pregnant
Child
Elderly
Life Stage
Socioeconomics
Access to Preventative Care
Exposure Characterization
Activity Patterns
Acute
Intermittent
Chronic
Cumulative
Dosimetry
Co-exposures w. NAAQS & others


Coordination Between Agencies & Stakeholders
Consistency
Budget/Funding
Data Management
Confidentiality
Sharing Policy
Storage of Records
Legacy of Reporting
Multiple Levels of Society
International
National
Regional
State
Local
Tribal
Who is Involved in the Coordination?
EPA
CDC
USDA - USFS
Tribal Organizations
NIH
NIEHS
FWS
NWS
DOS
OSHA
FEMA
NASA
NOAA
International (Canada & Mexico)
NRS
NGOs
ECOS
Powergrid officials
Transportation Officials
Homeowners
Business owners
In the Path (downwind)
At-risk populations (lifestyle pregnant, children, elderly, pre-existing conditions)
Conservationists, Recreationists
"General Public"
ASPHO***
AAPCA
NACAA
NIOSH
BIA
CALFIREt
CARPA
IASC
First responders
fire fighters, EMTs, hotshots
Healthcare Professionals
Academic Institutions
Local/Community Organizations
HOAs, CWOOs, FACs
K-12 Schools
Power suppliers
Stakeholder Roles/Responsibilities
Managers
Researchers/ Scientists
Citizens
Communicators
Consideration of Under-served, At-risk and Minority Communities
Chain of Command
Lead Agency
Identification/ Category of Event
By Agency
By Geographic Location
Exceptional Events
Prescribed or Wild
Trust
Timing
Pre Fire
During Fire
Post Fire
Preparation
Lessons Learned
Multiple Missions
Protect Ecosystems
Protect Human Health
Connections/Partnerships
Existing
Strengthen
Highlight
Creating new linkages
Maximize Expertise
Evacuation
Road Blockages/Closures
Hospital/Medical Facilities
Clean Air Shelters
Air Filtration Devices
Respirators
Transportation
Infrastructure/Equipment
At-Risk Population
Evacuation
Ambulance/EMT
Emergency Services
Food/Diet
Medication
Masks
Provisions
To Reduce Exposure
To Reduce Effects of Exposure
Public Health Interventions
Weather/Climate
Fuel Loads
Environmental Conditions
Livestock
Pets
Animals
Budget/Funding
Exceptional Events
Policy
Pre Fire
During Fire
Post Fire
Timing
Road Blockages/Closures
Transportation
Fire Fighters
Hot Shots
Emergency Services
Air Fleet
Camps
Infrastructure/Equipment
Access to Water
Access to Masks (N-95)
Access to A/C
Access to HEPA Filters
Provisions
Fire/Smoke Interventions (reducing hazard)
Data Management
Sharing Policy
Storage of Records
Legacy of Reporting
Government Agency Interventions to Mitigate Exposures & Health Effects

Appendix C – Questionnaires and responses

Feedback Form

Please take a few minutes to provide us with feedback on this workshop. This input will help us plan and improve future workshops.

The goal of this workshop was to identify opportunities for research and technological solutions that will improve health-risk communication strategies, increase health-protective behaviors, and reduce the public-health burden during wildfire smoke episodes.

Please circle your level of agreement with the following statements about the workshop.
(5=strongly agree; 4=somewhat agree; 3=neutral; 2=somewhat disagree; 1=strongly disagree; NC=no comment)

	strongly agree				strongly disagree	
1. The workshop achieved its goal (above)	5	4	3	2	1	NC
2. The workshop reflected broad participation.	5	4	3	2	1	NC
3. All voices were heard during the workshop.	5	4	3	2	1	NC

For any aspect that you disagreed with, please tell us what specifically could be improved.

Please circle your rating for each element listed below. (5=excellent; 4=very good; 3=good; 2=fair; 1=poor; NC=no comment)

4. Effectiveness of the mind map approach in supporting the workshop goal	5	4	3	2	1	NC
5. Utility and design of the workshop SharePoint site	5	4	3	2	1	NC
6. Day 1 Sessions						
a. Contextual Presentations	5	4	3	2	1	NC
b. Breakouts: Drafting a Problem Statement for Critical Focal Areas	5	4	3	2	1	NC
c. Day 1 Report-Out and Discussion	5	4	3	2	1	NC
d. Fire Talks	5	4	3	2	1	NC
e. Demos/Poster Session	5	4	3	2	1	NC
7. Day 2 Sessions						
a. App Presentations	5	4	3	2	1	NC
b. Keynote	5	4	3	2	1	NC

c. Breakouts: Identifying Research & Development Opportunities	5	4	3	2	1	NC
d. Day 2 Report-Out and Discussion	5	4	3	2	1	NC
8. Workshop room set up	5	4	3	2	1	NC
9. Overall workshop experience	5	4	3	2	1	NC

For any elements rated fair (2) or poor (1), please tell us what specifically could be improved. (Write below.)

What was your favorite part of the workshop?

Did you prepare a mind map? (Circle one.) Yes No

If yes, did you find it helpful in identifying the various facets of the problem?

Do you feel that the "problem-formulation" approach (mind-map, breakout groups) was more or less successful compared to prior workshops wou have attended designed to achieve the general goal of identifying opportunities for research and technological solutions to public health or environmental problems?

Please use the space below to provide any additional comments, or if you ran out of space for questions above

Feedback form, numerical responses, questions 1 through 9

Q1	Q2	Q3	Q4	Q5	Q6a	Q6b	Q6c	Q6d	Q6e	Q7a	Q7b	Q7c	Q7d	Q8	Q9
4	3	5	2	4	5	4	3	4	4	4	5	3	4	4	4
4	5	4	4	NC	5	3	4	5	5	3	5	5	5	5	5
NC	5	5	5	3	4	4	4	4	4	4	4	4	4	4	4
5	5	5	4	3	5	4	3	3	4	4	5	5	5	5	5
4	4	4	3	3	4	4	4	3	3	2	4	4	4	3	4
5	4	5	4	4	5	5	5	4	5	5	5	5	5	4	5
4	4	5	NC	2	5	4	2	3	5	4	4	4	4	4	5
5	5	5	4	4	5	5	2	4	4	5	5	4	4	4	5
5	5	5	4	2	4	4	4	5	4	4	5	5	4	5	5
4	5	4	NC	3	4	4	3	4	4	3	4	5	5	4	4
5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5
3	4	4	2	2	3	4	2	2	NC	2	5	3	NC	3	4
NC	4	4	3	3	4	4	3	4	5	NC	NC	NC	NC	5	4
3	4	4	1	3	3	4	4	2	2	4	4	4	NC	4	4
3	2	4	4	3	4	4	3	4	4	NC	NC	NC	NC	4	4
3	5	NC	3	4	5	4	3	5	4	4	5	5	4	4	4
4	4	5	4	3	5	5	4	5	5	4	5	5	4	4	5
4	4	4	4	2	NC	5	4	3	2	4	5	5	NC	3	4
5	5	5	5	5	5	5	5	5	3	4	4	4	4	5	5
4	4	5	4	3	3	4	4	3	4	3	4	3	3	4	4
4	5	4	5	4	5	4	4	5	5	4	5	4	4	5	5
4	4	4	5	4	3	4	4	4	NC	4	4	5	3	4	4

Questions 1-3: 5=strongly agree; 4=somewhat agree; 3=neutral; 2=somewhat disagree; 1=strongly disagree; NC=no comment

Questions 4-9: 5=excellent; 4=very good; 3=good; 2=fair; 1=poor; NC=no comment

Feedback form, text responses

For any aspect that you disagreed with, please tell us what specifically could be improved.

- I had to leave before Friday's discussion, which I think will contribute to this. [The workshop reflected broad, multidisciplinary participation. Answer =2]
  I think it is important to consider smoke from all sources and think of wildfire emissions within broader context that considers total emissions- wildfire, prescribed fire, etc. I think it would be important to include fire management personnel and fire research funding (Joint Fire Science Program)
- The goals were a little unclear. That was OK, since there were multiple goals for multiple people. And ORD's goal wasn't necessarily going to motivate people to attend. The meeting did meet many of the goals. It worked out well.

For any elements rated fair (2) or poor (1), please tell us what specifically could be improved.

- Too cold!
- SharePoint- I couldn't get into it. Simpler collaborative tool would be better.
  Report back- late in day. Low energy. Tough to stay focused.
- Looking forward to continued collaboration [respondent had no ratings below 4]
- Share poster info before conference as well please
  SharePoint of course has limitations. Find a third party (organization) who can use a more robust, interesting platform (rest of comment cut off in scanned version)

What was your favorite part of the workshop?

- Mind mapping, contextual presentations, second day breakfast
- Great coverage
- Interaction with others that I don't normally talk to (e.g., economist)
- Workgroups but needed more time
- Greg Fishel Keynote
- Whole event. Meeting new people. Great connections.
- Networking
- The small breakout sessions to discuss both the problem and research directions
- Breakout groups- discussion is good
- Hearing from people from other disciplines, such as behavioral scientists or risk communication scientists
- Contextual discussion- lots of great information presented.
- Day 1 presentations - will we have an opportunity for a follow-up meeting
- Interdisciplinary approach, variety of participants
  Networking with other people in my field and outside of my field
  Pushing me to think about smoke risk com. in bigger different ways
  Representing different aspects of the smoke risk com. landscape
- A good mix of disciplines and well facilitated so that those perspectives were shared and heard.

- I appreciated that there were a broad range of disciplines represented, but I think including more communication professionals would be good for the next event.

Did you prepare a mind-map?

- Yes: 15/22

If [you prepared a mind-map], did you find it helpful in identifying the various facets of the problem?

- No (1 respondent)
- Yes (3 respondents)
- Yes, great way to gain early consensus on scope and areas to cover
- Not sure
- Very helpful- hard thought process but well worth the effort
- Not especially. I've given it lots of thought before.
- It clearly laid out areas for discussion and helped with identifying the breakout groups
- Not really. However it was useful for collecting thoughts prior to workshop
- Not really. But it was nice to take a moment to think along those lines.
- Yes, it was a new concept but working through the process helped me understand its utility.
- Yes, need to add evolution? aspect as its own research/box.
- Not as much - wildfire vs. prescribed - both similar, yet very different with respect to com. Post fire vs preventative measures
- When I did my part of the map, I was skeptical; however, once I saw the group map, I understood more how the approach would be useful. That usefulness became particularly clear to me when I saw the breakout groups.

Do you feel that the "problem-formulation" approach (mind map, breakout groups) was more or less successful compared to prior workshops you have attended designed to achieve the general goal of identifying opportunities for research and technological solutions to public health or environmental problems?

- Yes, but also think we identified some problems that aren't going to be solved by research (although it will help with some). Hope we don't lose track of those issues in the workshop report.
- More successful
- I felt that we actually accomplished something at this workshop
- Mind map was not summarized need to hear what was discovered in map
- Yes - worked very well
- I liked this process a lot. Kept everyone engaged.
- Yes it worked well though I have only a few experiences with problem formation development.

- I thought we identified a lot of important areas where research should be focused due to deficiencies in the current science. The hard part will be moving forward and identifying how to tackle this issue, which issues to focus on, and funding research.
- I found the breakout sessions to be useful and well structured.
- Yes, I think it helps to focus discussions around things we want to improve. It focused thoughts and minimized rambling.
- I believe it was "more" successful. Anxious to see report and what happens with follow-up.
- The unique variation of disciplines was most beneficial- interaction and face to face brain-storming was most beneficial.
- Yes it worked much better than anticipated! See my comments about the mindmap. I appreciated the openness of the workshop participants a lot; their willingness to discuss, to collaborate on developing ideas and statements.
- Yes. It is impressive to see the final mind map that incorporated the "mini" mind maps.

Please use the space below to provide any additional comments.

- Workshop needed to be 1/2 day longer
- Thank you! Thank you for the hard work putting it together, thinking creatively to achieve the workshop goals, and putting so much positive energy into the meeting. And thank you for all the hospitality.
- Dynamic, interactive, incredible!
  Hotel was not the best.
  More breaks on the first day- lots of coffee.
  Maybe dividing breakout messaging into wildfire vs prescribed fire groups (2 different).
  Group dinner- great!
  Short informational presentations - great!
  A new approach that's ""people-based"" and not just science-based. Genius! (citizen science)
  One of the best workshops (most productive) I have attended for a long time.
  Funding for travel was essential for me to be approved to attend.
- Very well-run workshop! Thanks!
  The timer was very helpful.
  My only comment on the construction of the breakout groups was the boundaries between groups (each one's turf, so to speak) was hard to understand at times. I think some groups had trouble knowing where to concentrate, so their work might not have been as useful to defining key questions in their areas.
- Well-organized event that lent well to useful information sharing. Since different perspectives were shared, I learned a few more things. Great way to balance the impact. Logistics were well planned.