Outcome of the Wildland-Fire Smoke Workshop

Main findings from the workshop:

1. Inhalation of smoke from wildland fires (which include both wildfires and prescribed fires for land management) has acute and likely chronic effects on human health, yet there are information gaps that prevent us from effectively taking steps to protect human health.
2. Our understanding of acute and chronic health effects of smoke inhalation is limited by (1) knowledge of ambient smoke concentrations and personal smoke intake rates from past fires, and (2) availability and quality of health-outcome data.
3. Smoke-warning systems can allow the public to take protective actions to reduce smoke exposure; however, uncertainties in smoke forecasts and lack of best practices for messaging and education limit the efficacy of these systems.
4. Public officials need to know when, where, and how much forest / vegetation can be burned through prescribed fires without putting nearby communities at risk of smoke exposure. Uncertainties in smoke forecasts lead to inadvertent smoke exposure of nearby communities.
5. Smoke-forecast quality is limited by uncertainty in four keys areas: weather forecasts, fire spread prediction, emissions rates of particulate- and gas-phase species, and predictions of plume rise.

Background

Smoke from wildland fires negatively influences the health of people in the western US and other smoke-prone regions in the world. While air pollution from urban and industrial sources is expected to decrease in the coming century, smoke from wildland fires (wildfires in particular) is predicted to increase. The increase in population density within smoke-prone areas (e.g., population growth in the western US) will further exacerbate these health effects. However, there is still much uncertainty surrounding the impacts of wildland-fire smoke on humans and the earth system, as will be briefly summarized in this report.

The study of wildland-fire smoke issues includes many disciplines and sub-disciplines, and their interactions. They include, but are not limited to: epidemiology, forest ecology, climate, weather, atmospheric chemistry, land management, communications, economics, and public health. Concerted coordination between these disciplines is essential for finding solutions to and minimizing the ill effects of this ever-growing problem.

Additionally, many federal, state, and local agencies within the US devote significant resources to managing the issues posed by wildland fire smoke. The increased resources have invigorated the wildland fire science. Wildland fire is also a global problem that is being addressed in some other countries, notably Australia and Canada. However, many developing countries that desperately need information and expertise to deal with wildland-fire smoke lack such information.

Given this background, a workshop of about 50 stakeholders and researchers was organized by Colorado State University and held on August 12-13, 2015, in Longmont, Colorado.

Findings of the workshop

Important information emerged from the workshop. This information is briefly summarized, by topic, below.

1. **Human health impacts of wildland-fire smoke exposure:** Inhalation of smoke has been shown to impact cardiovascular and respiratory health in humans; however, the risk of these diseases with varying levels of smoke exposure is uncertain. Additionally, it is unclear if/how health impacts of smoke differ from anthropogenic air pollution, and whether these risks vary between fires and with smoke age. To improve our understanding of the health risk of smoke exposure, data of appropriate quality are needed on smoke exposure (both at personal and population levels) as well as accurate and descriptive data on health outcomes (e.g., hospitalizations, doctor visits, and prescription refill and usage rates). Thus, researchers in atmospheric science, air pollution exposure, and epidemiology must work closely together on improving these estimates. An additional open question is the quantification of the chronic health effects from smoke exposure, as most studies have currently focused on the acute health effects (i.e., those incurred within weeks of smoke events).

2. **Protection of human health during smoke events**: Individuals and decision makers may take actions to protect themselves and others from the health effects of smoke, which include, but are not limited to, air filtration in homes and public buildings, modified behavior to avoid smoke, and even evacuation. The likelihood that individuals and key decision makers (e.g., public officials) will take actions depends on the following: (a) perceptions of the health risks from wildland-fire smoke, and (b) beliefs that smoke exposure can be mitigated. Effective messaging to encourage exposure mitigation depends on a clear understanding of the social-psychological context in which individuals and decision makers operate.

3. **Smoke health-risk messaging and education**: There are considerable efforts at national, state, and local levels on smoke forecasting and messaging. Forecasting efforts include use of atmospheric transport models with information on fire and smoke locations from satellites and in-situ measurements. Forecasts are currently subject to errors due to imperfect weather forecasts, fire spread, smoke injection heights, missed fires, and smoke emissions rates. Improvement is likely necessary in each of these areas. Additionally, there is considerable research that must be done regarding how best to communicate smoke risks, both when smoke exposure is and is not imminent. Improved education and messaging of the steps that individuals can take to protect their health could lead to reduced health impacts.

4. **Wildfire characteristics**: Causes and characteristics of wildfires are interlinked but diverse. Key questions include: What are the factors that determine the extent of burns? When and where do the fires occur? Where are their impacts felt and across what time scales? The factors that determine wildfire occurrences include: climate (drought; soil moisture) and weather, fuel load, land-management practices, and individual actions that include deliberate or inadvertent starting of burns.

5. **Prescribed burns**: Prescribed burning is a human intervention to reduce the occurrence of large wildfires by reducing fuel loading. Because prescribed burns are under human control, they are generally easier to manage. However, human exposure to smoke from prescribed burns is sometimes severe, especially when local forecasts fail. The decision makers of prescribed burns need to know when, where, and how much to burn while still keeping smoke in nearby communities at an acceptable level of safety for public health. Thus, these decision makers require improved local-scale smoke forecasting to minimize the risk of smoke exposure of nearby populations. Early warning systems of imminent smoke may also be helpful for minimizing impacts on the surrounding populations. Prescribed burns also provide research opportunities for improving fire science and exploring smoke exposures.

6. **Other land-management practices**: There are many issues regarding land management beyond prescribed burning that impact smoke exposure. Open issues in this area include agricultural fire smoke, the long-term impact of mechanical forest thinning and prescribed burning on wildfire smoke emissions, and potential regulation of property development management to mitigate smoke risk (e.g., air-filtration systems).

7. **Inventories of wildfire emissions (PM and gas phases chemicals)**: At the workshop, information on smoke emissions from wildland fires was discussed. This included both emission factors (emissions per mass of wood burned) and emission inventories (spatially and temporally resolved emissions). Many issues, including those noted below, emerged from the discussions: (a) Much information on emission factors of smoke species is already available but they are not yet used widely, or wisely. A future activity could be organized to collect and evaluate the data quality, and to disseminate such data more effectively; (b) It will be very useful to provide guidance to scientists (who are collecting data during research projects) about what information they should be reporting and in what form they should be reporting data for easier calculation of exposure. Often, stakeholders do not (or cannot) use available data because they are not in the right format or the researchers do not convert their data into forms useful to the stakeholders; and (c) Further information is still needed on particulate matter and VOC source profiles from prescribed burns and wildfires. Indeed, such information may be available but not published.

8. **Knowledge gaps:** There are many gaps in our knowledge beyond those reported above that are needed to mitigate and cope with wildfires. They include science gaps from the providers' points of view and information gaps from stakeholders' point of

view. Technology gaps also exist in generating information that can be provided to stakeholders and smoke-impacted individuals (e.g., reliable, low-cost sensors).

9. **Missing or under-represented stakeholders**: The workshop tried to be comprehensive in inviting participation of key stakeholders. However, given time and fiscal and logistical constraints, there were some key players missing in our dialogue and some areas were under-represented. They include: (a) higher-level policy makers; (b) policy makers from schools, communities, states, and others; (c) representatives from the Centers for Disease Control and the National Institutes of Health; (d) media; (e) firefighters who are in the front line of these issues; (f) key international experts who have dealt with these issues (in particular the Australians who have wildfire issues similar to those in the western US); and (g) and people who plan and submit prescribed burn plans.

10. **Missing science issue**: There are some scientific issues that were not either discussed at all or were not discussed at sufficient depth. They include: (a) meteorology, including boundary layer meteorology (e.g., trapping of smoke in the boundary layer and drainage flows were mentioned as important issues); (b) plume-rise forecasting and hindcasting (including pyroconvection); (c) a standing capability to measure emissions from burns; and (d) science related to components in smoke that are not currently (or even historically) considered. A more comprehensive list of the science needs can be put together from the material presented at the workshop. Such a list will be developed in the process of taking the next steps from the workshop.

A few overarching points emerged from the workshop. They include: (a) The various stakeholders in the area of wildland-fire smoke have different but complementary needs. There would be further benefits from coordination between stakeholders to leverage information to meet these needs; (b) Various researchers and funders also have different but complementary goals. There would be major benefits from coordination between various research funders to get more information from the studies they have funded or plan to fund in the future; and (c) Awareness of the available information and needs of the stakeholders allows for more-efficient use of funding resources.

Steps that can be taken to minimize overall human exposure to wildland fire smoke *(items that emerged from the workshop)*

1. Much information about wildland-fire smoke and its impacts is available but some gaps remain. These information need to be synthesized and gaps need to be addressed.
2. The available data are not used as effectively as possible. Further education and coordination is needed between the people who generate the information and people who use the information.
3. Health impacts from smoke inhalation are the first order of concern. However, there are other impacts – on climate, water quality, and visibility – that are also important aspects of wildland fire and are worthy of future exploration.