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Supplementary Material

Limited availability of health risk communication related to community smoke exposure from prescribed burns in the United States: a review

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SM-A: Supplementary Methods

We referenced the American Journal of Managed Care (AJMC) to define vulnerable populations, which is defined as older adults, children, individuals with pre-existing medical conditions, immunocompromised individuals, racial and ethnic minority groups, and economically disadvantaged communities (AJMC 2006). Outdoor occupations are another potentially vulnerable population, however, occupational exposure related to firefighting and other emergency response activities was beyond the scope of this review (but see Navarro *et al.* 2019) and therefore we did not include this group since the focus is on community exposure.

We initially found 8,831 peer-reviewed literature articles in PubMed, Scopus, and Web of Science. After reviewing the results based on title and abstract, we excluded 8,703 articles leaving 127 articles to review for duplicates across the three databases. Among these articles, the research team found 68 articles duplicated across the three databases and excluded these from further review. We reviewed the full text of 59 articles. Of these articles, we excluded 32 because their topics were not related to health risk communication for either prescribed burns or wildfires. We included a final total of 27 articles in the review.

SM-B: Additional Description of Environmental Scan Materials & Peer-reviewed Literature

Suggested guidance for effective communication

Several of the environmental scan materials are designed for practitioners (e.g., including public health, land management, and NGOs) to communicate information about prescribed burns (e.g., resource hubs, toolkits, overview documents, infographics, guidelines). For example, the Colorado Department of Public Health and Environment provides guidance on health messaging, specifically for prescribed burns, that includes distribution options (e.g., letter template in English and Spanish, flyers, etc.), timing of distribution (e.g., communication must be released a week before fire ignition), a link to a webpage on tips for how to reduce smoke exposure (e.g., close windows and doors, use HEPA air filters, etc.), vulnerable individuals (e.g., older adults, children, pregnant women, and individuals with pre-existing respiratory or circulatory conditions), and symptoms of smoke exposure (e.g., coughing, difficulty breathing, and eye, nose, and throat irritation) (Colorado Department of Public Health and Environment n.d.*a*; Colorado Department of Public Health and Environment n.d.*b*). The Oregon Department of Forestry also provides a communication framework for smoke management of prescribed burns that includes importance of messaging, sources for additional information (e.g., smoke-sensitive areas), potential smoke-related health risks, vulnerable individuals, and recommendations risk reduction (Oregon Department of Forestry 2022).

The Great Plains Fire Communication Kit provides guidelines on building both proactive and reactive fire messages for prescribed burns. Proactive messaging is an important aspect of communication prior to a prescribed burn because it explains the value of prescribed burns, but

also describes potential risks and highlights precautionary safety measures (Schwedler *et al.* 2013). The Great Plains Fire Communication toolkit provides examples for news releases, magazine articles, brochures, displays, television, radio, and internet links. A critical point this toolkit emphasizes is ensuring the first public message establishes the value of utilizing prescribed burns so that surrounding communities understand its purpose and the risks involved (Schwedler *et al.* 2013). Subsequent messaging can then entail any risks involved with the burns, precautions that need to be taken, and solutions that prescribed burns can provide to natural or economic problems (Schwedler *et al.* 2013).

Similar to the Great Plains toolkit, the Texas A&M University toolkit discusses effective communication strategies for prescribed burns. For example, effective verbal communication should include transparency and empathy of the issue, flexibility in understanding other opinions, and affirming responses (Treadwell *et al.* 2021). The Oakridge Air toolkit, developed to support the Oakridge-Westfir community in Oregon, provides templates and example messaging for prescribed burn communications distributed via social media, text alerts, and press releases (Oregon Prescribed Fire Council n.d.). Additionally, Oregon's Department of Forestry releases an annual statewide communication framework that describes the importance of prescribed burns, health risks related to fire smoke, recommendations for risk reduction to smoke exposure, and systems for communicating prescribed burn plans as well as up-to-date information on smoke events (Oregon Department of Environmental Quality n.d.). As part of their prescribed fires campaign, CAL FIRE developed a campaign toolkit that provides graphics, public service announcements, and other materials that fire agencies and stakeholders can use to disseminate key messages. These include outdoor advertisements, email blasts, short videos,

various social media advertisements (e.g., Facebook, Instagram, and Twitter), and online banner advertisements (CAL FIRE 2019). Because social media is a current major source of information, this document also recommends using several social media outlets to access as much of the community as possible (Stone *et al.* 2019). It also states that social media outlets are a good way to direct people to a central source (e.g., website or document) of information (Stone *et al.* 2019). Based on the environmental scan materials and peer-reviewed literature articles there is a consensus that fire and health risk communication should utilize all media platforms to reach a wider audience and that messages should remain transparent. However, our review of the environmental scan materials and peer-reviewed literature suggests that individuals developing and distributing the communication materials should also be aware that there are limitations, such changes or inconsistency in messaging when shared on several platforms and by multiple sources. This also supports our recommendation of increased inter-agency collaboration to ensure consistent messaging, which is further detailed in the discussion section of this review.

Among the peer-reviewed literature, all information on the efficacy of communication was extracted from articles related to wildfires. The research team did not find any peer-review articles that discussed the efficacy of communication for prescribed burns. However, we did conclude that some of the information can be applied or adapted for prescribed burn communication. In this review, we report the information that can be adapted. Frequency of messaging, source of information, and message content are important aspects in health risk communication. Heaney *et al.* (2021) found that message content can directly impact how effectively health information is communicated to the community. Effective messages tend to be tailored to a specific area, clear, specific, consistent, and contain information that includes a

timeframe, location, and hazards (Heaney *et al.* 2021) (e.g., BLM prescribed burn announcement for Meeker, Colorado; Southern Fire Exchange FAQ for prescribed fire in Georgia). Although developed for wildfires, an example of this is the "Ready, Set, Go" campaign in Texas, which uses only three short points to communicate public health safety: "Be ready for a fire threat, have situational awareness if a fire threat occurs and be 'set' to leave if you need to, and go early – leave at risk areas early" (Finlay *et al.* 2012). In addition to short and consistent messages, Reid and Maestas (2019) also emphasize that messages should be attentive to vulnerable populations. For increased efficacy, the recognition and use of existing social and communication networks is important for providing greater reach to remote or rural areas (Olsen *et al.* 2014). Chauhan and Hughes (2017) found that event-based resources, such as Facebook pages, can provide a high volume of relevant information pertaining to smoke events. Push notifications on local phone apps are also used to inform users of harmful air quality levels (Humphreys *et al.* 2022). Communication resources, like the CDC's Communication Index, were developed to aid local communities in developing handouts, social media posts, and traditional announcements (Rice *et al.* 2021). Other efficacious methods of communicating health risks that are applicable to prescribed burns include informational campaigns and community events where individuals can learn more about interpreting the air quality index and pick up resources on health information and clean air locations (Humphreys *et al.* 2022). The AirNow partnership published a document entitled *Wildfire Smoke: A Guide for Public Health Officials* which is designed to help public health officials prepare for smoke events and communicate associated health risks to the public. This document emphasizes the importance of pre-season fire messaging via public service announcements and social media posts so that surrounding communities can prepare for the upcoming fires (Stone *et al.* 2019). Reactive messaging, which is mainly used for wildfires, uses

empathy and focuses on immediate safety while trying to prevent panic (Schwedler *et al.* 2013). Reactive messaging is mostly utilized for wildfires but can be applied to prescribed burns that get out of control, which are exceedingly rare.

The efficacy of communication can often depend on its flow. Communication can flow in one of two ways: unidirectional and multidirectional (**Fig. S1**). Unidirectional communication is a form of passive communication often disseminated en masse via flyers, radio announcements, or any form in which the public cannot directly interact with the source (Remenick 2018). Multidirectional communication is often integrative, allowing recipients of the information to interact with the source (Remenick 2018). There are advantages and disadvantages to both types of communication that strengthen and limit their efficacy. Unidirectional communication is beneficial for deploying information to many people, especially when there is an issue of timeliness (Remenick 2018). However, it does not allow for any conversation between sender and recipient if there is confusion or questions about the message. Integrative communication allows for interaction, which can ultimately increase trust leading to better compliance with smoke event guidelines (Remenick 2018). Although this may be the preferred form of communication in some instances, it can be costly and time consuming.

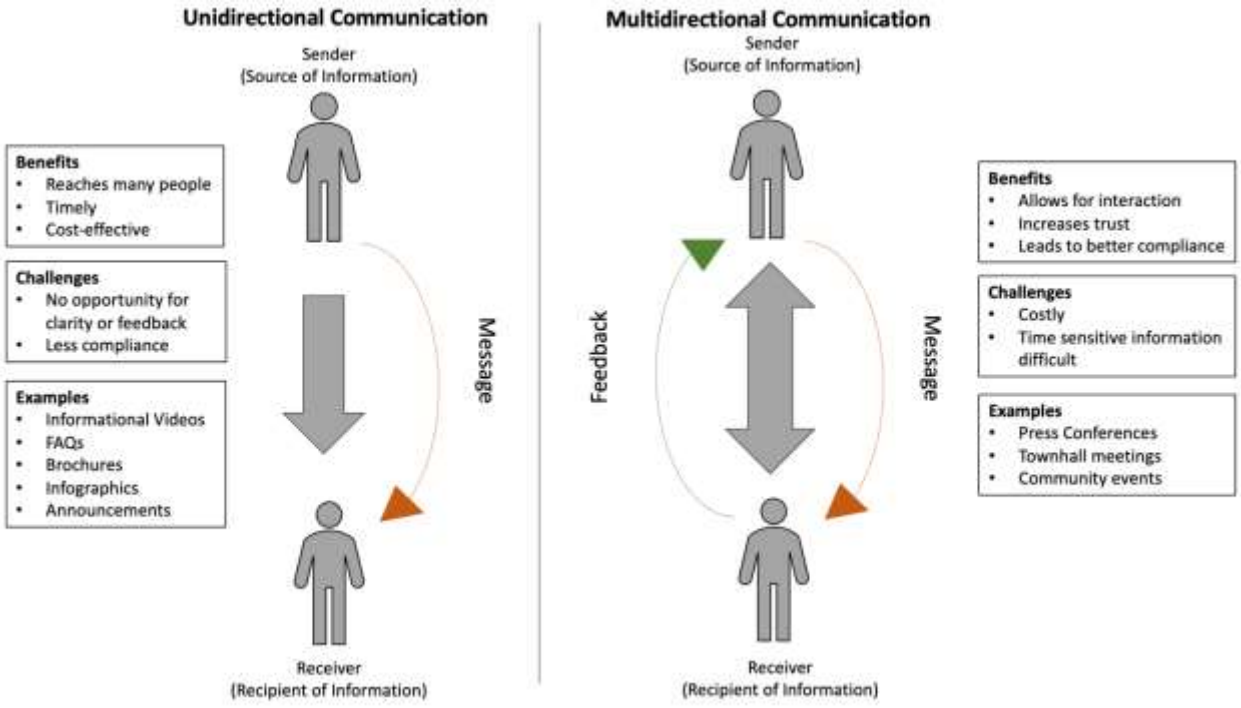

Figure S1. Unidirectional versus multidirectional communication

Communication can also flow vertically or horizontally. Vertical communication is very similar to the concept of unidirectional and multidirectional communication in that experts are communicating information to the public in a top-down manner. Horizontal communication, on the other hand, is more interpersonal and relies on social interactions.

Safety precautions, preparedness, and interventions

There are distinctions between wildfire smoke and prescribed burn smoke based on burn time, smoke dispersion, acreage burned, etc. and therefore there are differences in plans regarding communication, preparation, and mitigation strategies. Another major distinction between smoke from wildfires and prescribed burns are the types of materials that are burned, with built environment materials being burned by wildfires at the wildland urban interface (WUI) (Hill *et*

al. 2022). This is not an issue that is associated with prescribed burns since these they are usually contained to a specific area. There is a misconception that all fire is negative, and the BIA created an educational video to address this misconception. The video, *Native Fire*, explains how indigenous communities used prescribed burns to their benefit and how prescribed burns can benefit modern communities. The video defines prescribed burns, as well as details the Pacific Region BIA "4 Rights" campaign which includes: 1.) knowing the right time of year and day to burn for the results to be beneficial (e.g., reduction in fuel sources, vegetative species management, etc.), 2.) knowing the right area to burn considering local fuels, topography, and needs to sustain a healthy ecosystem, 3.) knowing the right cultural and scientific stakeholders to ensure fire safety and smoke management, and 4.) knowing the right reasons for prescribed burns such as cultural preservation and ecological management (Bureau of Indian Affairs 2019).

Multiple materials related mileage from visible smoke to safety precautions and warnings. A brochure from the Arizona Department of Health Services related ten or more miles of visibility during a smoke event to a good air quality index and minimal precautions, while 1.5-3 miles from visible smoke was related to an unhealthy air quality index and precautions were issued for vulnerable individuals (Arizona Department of Health Services n.d.). New Mexico Fire Information simplified this visibility method in a short infographic using the 5-3-1 method for visible smoke (e.g., 5 miles, 3 miles, or 1 mile) and the actions to take depending on the vulnerability of the individual (e.g., age, pre-existing health conditions, etc.) (New Mexico Fire Information n.d.). Based on the selections made by the individual, the recommendations were to frequently check for smoke visibility, minimize outdoor activity, or stay inside (New Mexico Fire Information n.d.). Provided in this protocol is a table that prescribed burn officials and

public health officials can use to determine when certain types of messages should be released to the public based on the air quality index, the 5-3-1 smoke visibility method, and if the projected smoke exposure is either under or over twenty-four hours. For example, if the air quality is categorized as “unhealthy for sensitive groups”, visible smoke is 3-5 miles away, and projected smoke exposure is under 24 hours, then the protocol recommends issuing a press release about precautionary actions for vulnerable populations (Oregon Department of Environmental Quality 2022). If the air quality index is categorized as “very unhealthy”, visible smoke is one mile away, and projected smoke exposure is under 24 hours, then the protocol recommends canceling outdoor events, monitoring indoor air quality, and sharing information with the public about improved air quality, risks, and safety precautions (Oregon Department of Environmental Quality 2022).

A fact sheet also published by PEHSU details how to perform a user seal check when wearing a mask. Pressure build-up inside the mask and feeling of air movement along the edges is an indicator of a positive user seal check (WSPEHSU, 2020*a*). A separate PEHSU fact sheet provides more details on wearing a mask for children and pregnant women, both of which are populations vulnerable to smoke exposure. It is recommended that children over two years of age and pregnant women wear an N95 mask, but in the situation where a child-size N95 mask cannot be found a surgical mask is recommended (WSPEHSU, 2020*b*). Pregnant women should also take precaution since difficulty in their breathing indicates that their babies are experiencing insufficient oxygen supply and measures should be taken to reduce that risk (WSPEHSU, 2020*b*).

Do-it-yourself (DIY) portable filters, that are built by attaching a furnace air filter to an electric box fan, can also be used as an affordable and accessible option to commercial filters (Davis and Black 2021). Regardless of which filtration system is being used, filters need to be changed at a frequency recommended by the manufacturer, which is typically 60-90 days, to ensure effective filtration. In conjunction with air filtration systems, “clean rooms” or “clean spaces” are recommended to reduce risk of smoke exposure. A clean room is one without fireplaces and a minimal number of windows (U.S. EPA n.d.). It is recommended that a “clean room” include a portable air cleaner and that no candles are burned, or food cooked to ensure the quality of the air remains as clean as possible (U.S. EPA n.d.).

Although many smoke management plans are developed in response to wildfire events, they are another aspect of preparation that can be applicable to prescribed burns. Smoke management or smoke readiness plans can be made for individuals, companies, or communities, and having an evacuation plan is essential. It should be noted that these types of plans would only be triggered in the accidental (low probability) event that a prescribed burn becomes a wildfire (i.e., an escaped prescribed burn or escaped fire) that could threaten life and property. While most existing smoke management plans that were identified are mostly written for (emergency) wildfires, aspects of the guidelines that are specific or applicable to non-escaped prescribed burns are discussed in section 3.3 of this review. The U.S.D.A. Forest Service reports that 0.13% (about 1 out 1,000 fires ignited) of prescribed burns turn into escaped fires each year, indicating that escaped fires are an infrequent event (U.S.D.A. Forest Service 2023). An EPA fact sheet offers that good evacuation plans consist of knowing procedures to receive alerts, public service announcements, and health warnings, as well as knowing all evacuation routes and having all

important items organized and ready for emergencies (U.S. EPA n.d.). The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) produced guidelines for creating a smoke readiness plan for organizations. These plans consist of maintaining HVAC systems and upgrading associated filters, having supplemental filters, limiting smoke intrusion, monitoring indoor $PM_{2.5}$, and creating temporary "clean spaces" (ASHRAE 2021). Community readiness and response plans are also ideal to have in place prior to a burn. Oregon's Department of Environmental Quality states that the purpose of a community response plan is to "promote communication between the entities that conduct prescribed fire, the local public health authority, vulnerable populations, and the public" (Oregon Department of Environmental Quality n.d.). However, the specific agency or jurisdiction that would typically be responsible for developing these plans was not stated in this document. Although this plan should be tailored to the specifics of each community, it should at minimum include descriptions of populations that are vulnerable to health effects of short-term smoke exposure; an adequate messaging system that clearly, reliably, and timely notifies the public, especially vulnerable populations, of anticipated smoke events; options for risk reduction and health protection from smoke exposure, especially for vulnerable populations; and a reliable system for communication between prescribed burn officials, public health authorities, and the public (Oregon Department of Environmental Quality n.d.). Smoke management and readiness plans are essential for risk reduction and ensuring safety at every level from the individual to a community, as seen from the materials produced by the variety of organizations ranging from local, state, national, and private entities. While some components may differ between an individualized response plan and a community response plan, the basic concepts of reliable, updated communication and understanding health risks and risk reduction remain the same.

SM-C: Supplementary Tables

Table S1. Summary of communication material sources from the environmental scan**.**

Type of communication material	**Sources**
Fact Sheets/Brochures	AirNow.gov Partnership
	Arizona Department of Health Services
	Arizona Interagency Wildfire Prevention
	Arizona Information Emergency Network
	Florida Department of Environmental Protection
	Oregon Department of Environmental Quality
	Southern Fire Exchange
	Science for Nature and People Partnership
	University of California, San Francisco: Western States Pediatric Environmental Health Specialty Unit
FAQ/Overview Documents	California Air Resources Board
	Centers for Disease Control and Prevention
	Colorado Department of Public Health and Environment
	Georgia Department of Public Health
	National Park Service
	New Mexico Fire Information
	Oregon Department of Environmental Quality
	Oregon Health Authority
	Southern Fire Exchange

	Texas Commission on Environmental Quality
	Department of Ecology of the State of Washington
	Washington State Department of Health
	University of California, San Francisco: Western States Pediatric Environmental Health Specialty Unit
	University of Florida, Institute of Food and Agricultural Sciences Extension
Protocols, Guidance, and Compliance Documents	AirNow.gov Partnership
	Cal Fire
	Colorado Department of Public Health and Environment
	Florida Department of Environmental Protection
	National Wildfire Coordinating Group
	Oregon Department of Environmental Quality
	Oregon Department of Forestry
	Southern Fire Exchange
	Virginia Prescribed Fire Council
	U.S. Environmental Protection Agency
Resource Hubs/Toolkits	Cal Fire
	Centers for Disease Control and Prevention
	Great Plains Fire Science Exchange
	Interagency Wildland Fire Air Quality Response Program
	Kansas Flint Hills Smoke Management
	National Wildfire Coordinating Council

	Science for Nature and People Partnership
	Texas A&M AgriLife
Graphics, Infographics, and Videos	Bureau of Indian Affairs
	California Air Resources Board
	New Mexico Fire Information
	University of California, San Francisco: Western States
	Pediatric Environmental Health Specialty Unit
	YouTube
Featured Stories/Articles/News	U.S. Environmental Protection Agency
	U.S.D.A Forest Service
Magazine Articles	AgriLife Today
	Science for Nature and People Partnership
Prescribed Burn Announcements	Bureau of Land Management
	National Park Service
	South Carolina Department of Natural Resources
	The Sea Pines Forest Preserve
	U.S. Fish & Wildlife
	U.S.D.A. Forest Service
	U.S. Department of Defense
Reports	Bureau of Indian Affairs
	California Wildfire and Forest Resilience Task Force
	Georgia Forestry Commission
	Oregon Health Authority

Reviews	California Dept. of Public Health Southern Fire Exchange U.S. EPA
Other	ASHRAE Florida Dept. of Agriculture and Consumer Services Physicians, Scientists, and Engineers (PSE) for Health Energy

Table S2. Summary of environmental scan materials by fire type.

Fire Type	Type of Communication Material
Prescribed burn	FAQ/Overview Documents; Featured Stories/Articles/News; Graphics, Infographics, and Videos; Magazine Articles; Prescribed Burn Announcements; Protocols, Guidance, and Compliance Documents; Regulations; Resource Hubs/Toolkits; Reports
Wildfire	FAQ/Overview Documents; Graphics, Infographics, and Videos; Protocols, Guidance, and Compliance Documents; Resource Hubs/Toolkits
Both	FAQ/Overview Documents; Featured Stories/Articles/News; Magazine Articles; Protocols, Guidance, and Compliance Documents; Resource Hubs/Toolkits; Reports

Table S3. Summary communication guidance for prescribed burn regulations found for the states included in the environmental scan.

State	Guidance on	Department/Division	Regulation Name,

	Communication or Education (yes/no)		Regulation Number
Alabama	No	Alabama Forestry Commission	Alabama Prescribed Burning Act, Section 9-13-270
Arizona	Yes	Arizona Department of Environmental Quality	Forest and Range Management Burns, R18-2-1501
California	Yes	California Department of Forestry and Fire Protection	Smoke Management Guidelines for Agricultural and Prescribed Burning, Title 17 §80160
Colorado	Yes	Department of Public Health and Environment; Air Quality Control Commission	Open Burning, Prescribed Fire, and Permitting, 5 CCR 1001-11
Florida	Yes	Department of Agriculture and Consumer Services; Florida Forest Service Division	Open Burning Allowed, 5I-2.006
Georgia	No	Department of Natural Resources; Environmental Protection Division	Air Quality Control, Rule 391-3-1-.02

Ohio	Yes	Department of Natural Resources; Division of Forestry	Notices, 1503.12
Oregon	Yes	Department of Forestry; Division of Smoke Management	Communication, Community Response Plans, and Exemption Requests, OAR 629-048-0180
South Carolina	No	Department of Health and Environmental Control	Air Pollution Control Regulations and Standards, Regulation 61-62
Texas	Yes	Texas Administrative Code; Prescribed Burn Board	Notifications Requirements Prior to Prescribed Burns, Rule §228.2
Virginia	Yes	Virginia Administrative Code; Department of Forestry	Notices Relating to Forest Fires and Trespasses, § 10.1-1112
Washington	No	Revised Code of Washington	Forest Protection Laws, RCW 76.04

Table S4. Summary of smoke management guidelines for states included in the environmental scan.

Summary of guidance	**State**	**Source**

Notify neighbors of prescribed burn plans at least five days prior to the burn day, as well as on the day of the prescribed burn. “Caution: Smoke on the Road” signs should be posted in the area on the day of the burn for public awareness of potential visibility problems.	Alabama	(Hanby & Alabama Forestry Commission, 2021)
Public notification of approved prescribed burns in the area	Arizona	(Arizona Department of Environmental Quality, 2022)
Smoke management plans are to include nearby population centers and procedures for public notification	California	(California Air Resources Board, n.d.)
• Public notification, especially in smoke-sensitive areas, should occur at least 24 hours, and no more than 120 hours, in advance of ignition of the prescribed burn, and should include location of the burn, expected duration, and projected smoke impacts • Options for public notification include: news releases, posted signs, and HOA newsletters	Colorado	(Colorado Department of Public Health and Environment, 2012)
• Smoke management program should include an explanation of the importance of prescribed burns and potential implications to public health and safety, as well as utilize posters, billboards, videos,	Florida	(Putnam, 2014)

pamphlets, news releases, and public presentations to communicate about prescribed burns. • Adjacent landowners, smoke sensitive areas, and adjacent jurisdictions are to be notified of planned prescribed burns prior to the event, and should include information on reducing smoke exposure for smoke sensitive areas		
• Public notification should be distributed to local residences, businesses, and other populated areas that may be impacted but smoke from the prescribed burn. Notifications can either be through personal contact or by leaving written notices. Notifications should include proposed date and time, location of the burn, contact information of the prescribed burn team, and why the burn is happening. For larger prescribed burns, notification should also be provided through the media. • The Georgia Forestry Commission is to promote public education and awareness of prescribed burns through public outreach including school programs, public speaking, landowner field days, fair exhibits, Prescribed Fire Awareness Week, and hands-on assistance for landowners who want to conduct	Georgia	(Georgia Department of Natural Resources, 2008)

prescribed burns. This does not preclude other organizations from also promoting prescribed burns, which they are encouraged to do.		
No statewide smoke management guidelines identified	Ohio	---
Communications framework should include information regarding: • Purpose and importance of prescribed burning • Health risks of prescribed fire smoke • Recommendations for the public and vulnerable populations to reduce their smoke exposure • How local officials and the public can receive information on current and upcoming prescribed burns in their areas • How residents in smoke-sensitive receptor areas (SSRA) and other interested individuals can receive up-to-date information on smoke impacts	Oregon	(OAR 629-048-0180, 2021)
No guidance provided for public notification or communication of prescribed burns	South Carolina	(South Carolina Forestry Commission, 2006)
Public notification should be distributed prior to the burn and on the day of the burn and include: • Written and verbal statement of prescribed burn operations and smoke production	Texas	(Texas A&M Forest Service, 2018)

• Post “Prescribed Fire in Progress” signs in proximity of state/interstate roads • Facebook and Twitter notifications for burn area		
Notify nearby groups that may be impacted by smoke (e.g., nearby residents, adjacent landowners, airports)	Virginia	(Virginia Department of Forestry, 1998)
• Public notification describing general burn location and approximate time of ignition • Provides guidance on purpose, message, scope, and timing of pre-burn season news releases, pre-burn season phone calls, and daily/weekly emails or social media notifications	Washington	(Franz, 2019)

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