Office of the Federal Coordinator for
Meteorological Services and Supporting Research

National Wildland Fire Weather: A Summary of User Needs and Issues

Joint Action Group (JAG) for the
National Wildland Fire Weather Needs Assessment (NWFWNA)

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Acronym List

4D	four-dimensional
ASCADS	Automated Sorting, Conversion, and Distribution System
ASOS	Automated Surface Observing Systems
CESORN	Committee for Environmental Services, Operations, and Research Needs
DTC	Developmental Testbed Center
FCMSSR	Federal Committee for Meteorological Services and Supporting Research
GEOSS	Global Earth Observing System of Systems
GIS	geographical information system
GOES	Geostationary Operational Environmental Satellite
GOES/DCS	GOES Data Collection System
ICMSSR	Interdepartmental Committee for Meteorological Services and Supporting Research
IEOS	Integrated Earth Observation System
IMET	Incident Meteorologist
ISOS	Integrated surface observing system
JAG	Joint Action Group
JAG/NWFWNA	Joint Action Group for National Wildland Fire Weather Needs Assessment
NAM	North American Mesoscale [model]
NCEP	National Centers for Environmental Prediction
NEPA	National Environmental Policy Act
NESDIS	National Environmental Satellite, Data, and Information Service
NFDRS	National Fire Danger Rating System
NOAA	National Oceanic and Atmospheric Administration
NWFWNA	National Wildland Fire Weather Needs Assessment
NWS	National Weather Service
OFCM	Office of the Federal Coordinator for Meteorological Services and Supporting Research
PDA	personal digital assistant
R&D	research and development
RAWS	Remote Automated Weather Station
ROMAN	Real-time Observation Monitor and Analysis Network
WFIP	Wildland Fire Implementation Plan
WFU	wildland fire use
WGA	Western Governors' Association
WRF	Weather and Research Forecasting [model]

Executive Summary

This report summarizes results from the wildland fire weather needs assessment conducted during 2006–2007 by the Joint Action Group (JAG) for National Wildland Fire Weather Needs Assessment (JAG/NWFWNA). To conduct the needs assessment, the JAG/NWFWNA gathered input from 745 Federal, state, tribal, and local fire weather users covering the full range of stakeholders in the national wildland fire weather community. The needs statements listed in table 1 and discussed in the body of the report reflect the JAG's analysis of the information gathered from the community, together with the expertise in wildland fire weather of the JAG members.

The JAG was tasked with assessing needs in nine functional areas:

1. Data collection, integrity, processing, and archival
2. Fire weather research and development
3. Forecast products and services
4. Modeling, prediction, and data assimilation
5. Information dissemination and technologies
6. Education, training, outreach, partnering, and collaboration
7. User response, decision support, and resulting user impacts
8. Funding and human resources (crosscutting)
9. Socioeconomic factors

Each needs statement (second column of table 1) is assigned a reference number (first column). The first segment of this reference number refers to the primary functional area to which that need is essential. Many of the needs are also relevant to other functional areas beyond this primary area, and all the relevant areas are listed in the third column of table 1.

The JAG considered with care which of the needs were truly urgent with respect to the imperatives of saving lives and preventing injury, whether to wildland firefighters or members of the public exposed to the various threats posed by wildland fire. Reducing loss of property or other economic losses was also considered, but was not given as much weight as the life and injury criterion. The JAG identified 14 needs as urgent by this stringent test. These urgent needs are noted in column 4 of table 1.

Each need is also characterized as to the time frame over which the need can feasibly be met. In the "Solution Time" column of table 1, "short" indicates the need can be met within one to two years, given adequate resources. "Long" indicates that more time will probably be necessary to meet the need fully. For some needs, something of value can be done quickly, even though fully meeting the need is a long-term challenge. Needs in this category are classified as "short/long" in table 1.

The "Scope" column in table 1 indicates whether the need applies broadly across the wildland fire community (a "common" need) or is primarily unique to a limited sector of that community.

The final column of table 1 lists the hurdles that the JAG considers to be most important to overcome in order to meet a stated need effectively and comprehensively across the national wildland fire community. The following "Contributing Factors" to each need are represented in the table:

- **Coordination**. A major obstacle to meeting the need will be *horizontal* coordination between agencies/entities at the same level (e.g., two or more Federal entities or entities across the State level), *vertical* coordination (e.g., Federal, State, and local entities working together), or both horizontal and vertical coordination.
- **Data.** Primarily, this factor represents observing data that are either not collected at sufficient spatial or temporal intervals, not collected routinely (observing systems not in place), or are not available to users within the time constraints of their data-dependent decisions.
- **Management.** Policies and/or management priorities and attitudes need to change in order for the need to be most effectively addressed.
- **Processes.** The way in which things are done now is a substantial part of the problem, and changing the process will be necessary to meet the need. A process constraint combined with coordination or management constraints can often be more difficult to overcome than a pure data or technology constraint.
- **Resources**. Meeting the need will require additional resources of funding (fiscal resources), proficient personnel (human resources), or both. It is often difficult to decide whether a resource constraint is really a management constraint (and vice versa), given that difficult resource allocation decisions must be made in accordance with managerial and institutional priorities.
- **Science.** Either our fundamental understanding is insufficient—and there is a need for basic research—or not enough is known about how to apply fundamental knowledge to solve a particular application problem—which defines an applied research need. At some point, applied research issues become technology issues.
- **Technology.** This term was intended primarily for circumstances where the technological capability generally exists but needs to be adapted or applied to the wildland fire need. If the way to do that adaptation is not yet known, then there probably is also an (applied) science factor as well.

Understanding the contributing factors for a need will be particularly important to developing an implementation plan to meet these wildland fire weather needs. The final section of the report discusses the sequence of steps necessary to formulate an interagency (and vertically integrated) implementation plan. It also suggests some framing concepts that will help to ensure the plan is both practical and effective.

Table 1. Summary of Identified Wildland Fire Weather Needs by Primary Functional Area

Need Ref.	Wildland Fire Weather Need	Functional Area(s)	Urgency	Solution Time	Scope	Contributing Factors
FA 1	**Data Collection, Integrity, Processing, and Archival**					
1.1	Improvements in data management are needed to establish a comprehensive, nationally beneficial observing system to meet the needs of wildland fire weather users.					
1.1.a	A strategy for a complete, real-time, observationally based, gridded characterization of the current atmosphere needs to be developed and implemented based on an integrated set of all available in situ and remotely sensed environmental data.	1, 5, 8		Long	Common	Coordination, Data, Management, Resources, Science, Technology
1.1.b	A centralized means of reliably retrieving validated observation data is needed.	1, 5, 8	Urgent	Short/Long	Common	Coordination, Data, Technology
1.1.c	A complete suite of deployable and non-deployable sensors must be well maintained and fully integrated into a national network for common data availability.	1, 5, 8		Long	Common	Coordination, Data, Resources, Technology
1.1.d	The comprehensive, prioritized list of needed observed and predictive fire weather data elements developed from this assessment should be refined and validated.	1		Short	Common	Coordination, Data
1.2	All national weather station standards (to include those used by other agencies and NFDRS standards) should be reevaluated to ensure proper integration of all pertinent weather station data (to include portable weather stations) for use by the wildland fire community.	1		Short/Long	Unique	Data, Science, Technology
FA 2	**Fire Weather Research and Development**					
2.1	The fire community needs a better understanding of the physical processes associated with fire potential, fire combustion, wildland fire smoke, and climate change/climate variability.					
2.1.a	The interaction between fire potential, fire combustion, and atmosphere needs to be better understood and modeled.	2	Urgent	Short/Long	Common	Data, Resources, Science

Table 1. Summary of Identified Wildland Fire Weather Needs by Primary Functional Area

Need Ref.	Wildland Fire Weather Need	Functional Area(s)	Urgency	Solution Time	Scope	Contributing Factors
2.1.b	A better understanding of wildland fire smoke is needed, and smoke prediction tools need to be refined and perfected.	2, 3, 7		Long	Unique	Data, Resources, Science
2.1.c	Wildland fire and climate change/climate variability is an issue of high concern, for which more scientific understanding is a priority.	2		Short/Long	Common	Data, Resources, Science
2.2	Users need easier and more centralized access to information on research initiatives, efforts, and successes.	2, 5		Short	Common	Coordination
2.3	Mature research needs to be integrated systematically into an operational environment for routine use by the fire community.	2, 5, 6		Short/Long	Common	Coordination, Processes
2.4	Users need to be integrated into research and development efforts to allow for effective feedback on operational usefulness.	2, 5, 6		Short/Long	Common	Coordination, Processes
FA 3	**Forecast Products and Services**					
3.1	Improved forecast products and services are needed across duty functions and at each level of government to meet the widely varying needs of fire operators and managers.					
3.1.a	Managers at each level of government need tailored products and tools for their unique duties and responsibilities; these products need to be made available to the entire community for greater use and awareness.	3, 1, 7		Long	Common	Coordination, Data, Processes, Resources, Science,
3.1.b	Information on forecast product accuracy should be made available to users.	3, 1, 6, 7		Long	Common	Coordination, Data, Resources, Science
3.1.c	Users need more detailed information regarding long-term forecasts and climate outlooks.	3, 1, 2, 6, 7		Short	Common	Coordination, Data, Science
3.2	Users need improved training and reference materials that facilitate proper interpretation and use of forecast products, as well as improved access to this material.					
3.2.a	Existing training and reference material for products and services need to be made readily available to all interested users.	3, 2, 5, 6	Urgent	Short	Common	Coordination, Resources

Table 1. Summary of Identified Wildland Fire Weather Needs by Primary Functional Area

Need Ref.	Wildland Fire Weather Need	Functional Area(s)	Urgency	Solution Time	Scope	Contributing Factors
3.2.b	Training and reference material for products and services need to be improved and expanded, based upon proven best practices from the field.	3, 6		Short	Common	Coordination, Processes, Resources
3.2.c	Training and information on interpretation and use should accompany all products and services, especially as new ones are implemented.	3, 6		Short	Common	Coordination, Resources
3.3	User feedback indicates that many useful products currently exist, but improvements are needed across a broad spectrum.					
3.3.a	Users value the availability and accuracy of NWS Fire Weather Forecasts and articulated the need for greater accuracy where possible.	3, 2, 5	Urgent	Short/Long	Common	Coordination, Data Management, Processes, Science
3.3.b	Users need statistical information on current accuracy and verification for NWS Fire Weather Forecasts.	3, 2, 5	Urgent	Short/Long	Common	Coordination, Data, Management, Processes, Science,
3.3.c	Users value Red Flag Warnings and articulated the need for fire weather warnings at longer lead times and with the widest possible dissemination.	3, 7	Urgent	Short	Common	Management, Processes
3.3.d	There is a specific need for improved smoke dispersion products.	3, 2, 7		Short	Unique	Coordination, Data, Resources, Science
3.3.e	Users need NFDRS forecasts for more locations.	3, 1		Short	Common	Processes
3.3.f	Users need improved fuel moisture data and forecasts that provide more timely, reliable, and spatially resolved information.	3, 1, 2, 5		Short/Long	Common	Coordination, Data, Processes, Science
3.3.g	Users would benefit from use of forecast upper-level atmospheric parameters and stability conditions.	3, 5		Short	Common	Coordination, Data
3.4	To help all fire weather forecasters meet the increasing needs of wildland fire managers, a more consistent and standardized set of product requirements is needed.					
3.4.a	Fire weather forecasters need to develop and support standard representations of fuels information along with standard meteorological conditions and fire weather threats.	3, 5, 6, 7		Short	Common	Coordination, Processes, Resources

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Need Ref.	Wildland Fire Weather Need	Functional Area(s)	Urgency	Solution Time	Scope	Contributing Factors
3.4.b	Fire weather forecasters need clear depictions of critical and standardized threshold/breakpoint conditions on their standard product suite of analyses, forecasts, and decision-support tools.	3, 5, 6, 7		Short/Long	Common	Coordination, Processes, Resources
3.4.c	The fire community needs to establish accuracy requirements for fire weather products and services to enable the provider community to focus improvement efforts where most beneficial.	3, 2, 5, 6		Short/Long	Common	Coordination, Processes, Resources
FA 4	**Modeling, Prediction, and Data Assimilation**					
4.1	Fire weather users and the meteorological community require the rapid transfer of fine-scale modeling, coupled fire-atmosphere modeling, and climate modeling advances into operations; emphasizing capabilities, limitations, and current improvement efforts.					
4.1.a	Users overwhelmingly need higher resolution meteorological model fields in complex terrain and the tools and input data to understand fire behavior and smoke dispersion.	4, 1, 2, 3, 5, 7	Urgent	Long	Common	Coordination, Data, Processes, Resources, Science
4.1.b	Users need model accuracy and confidence information presented to them in an understandable format.	4, 1, 2, 3, 5, 7		Short/Long	Common	Coordination, Data, Processes, Resources, Science
4.1.c	The fire community needs better modeling of fire potential, threat, and impacts associated with climate and climate change.	4, 1, 2, 3, 5, 7		Long	Common	Coordination, Data, Processes, Resources, Science
4.1.d	Model output information needs to be made available in easy-to-use graphics and in high-bandwidth and low-bandwidth formats for use with workstations, PDAs, and text messaging. Products also need to be available in GIS format.	4, 1, 2, 3, 5, 7		Long	Common	Coordination, Data, Processes, Resources, Science
FA 5	**Information Dissemination and Technologies**					
5.1	A coordinated, “one-stop” fire weather Internet presence is needed to facilitate fire weather user access to pertinent weather data and products for their region of interest.	5, 1, 2, 3, 4, 6, 7	Urgent	Short	Common	Coordination, Processes, Resources

Table 1. Summary of Identified Wildland Fire Weather Needs by Primary Functional Area

Need Ref.	Wildland Fire Weather Need	Functional Area(s)	Urgency	Solution Time	Scope	Contributing Factors
5.2	A centralized means for collaboration on products and services is needed.	5		Short	Common	Coordination, Processes, Resources
5.3	Consistent dissemination of timely products and services to model users is needed.	5, 3, 4		Long	Common	Data, Processes, Resources, Technology
5.4	More products need to be available in low bandwidth formats for users using telephones and/or PDAs to receive the data.	5, 3, 4		Long	Common	Data, Resources, Technology
5.5	Wildland fire weather users and providers require robust, real-time access to weather data, to include increased continuity of operations planning.					
5.5.a	Wildland fire weather users require a robust continuity of operations plan for the Geostationary Operational Environmental Satellite (GOES) Data Collection System (DCS), which serves as an integral mechanism for this flow of data.	5, 8, 1	Urgent	Short	Common	Coordination, Management, Resources
5.5.b	Wildland fire weather users require a robust continuity of operations plan for the Automated Sorting, Conversion, and Distribution System (ASCADS), which serves as a crucial node for weather data flow.	5, 8, 1	Urgent	Short	Common	Coordination, Management, Resources
FA 6	**Education, Training, Outreach, Partnering, and Collaboration**					
6.1	Fire weather personnel need to be properly trained, training programs need to be improved and validated, and eventually, a comprehensive training and certification program should be implemented.					
6.1.a	A review of training processes and programs for quality, availability, consistency, currency, and standards across the fire weather community is needed.	6	Urgent	Short	Common	Coordination, Management, Processes
6.1.b	Training programs need to be validated against requirements and improved via use of best practices.	6		Short/Long	Common	Coordination, Processes, Resources

Table 1. Summary of Identified Wildland Fire Weather Needs by Primary Functional Area

Need Ref.	Wildland Fire Weather Need	Functional Area(s)	Urgency	Solution Time	Scope	Contributing Factors
6.1.c	A comprehensive training and certification program needs to be developed, ensuring the fire weather competency of all fire weather personnel supporting wildland fire activities.	6		Long	Common	Coordination, Management, Processes, Resources
6.2	Training agencies need to make better use of a full range of training delivery methods, with a particular focus on distance-learning needs.	6, 5	Urgent	Short	Common	Coordination, Processes, Resources, Technology
FA 7	**User Response, Decision Support, and Resulting User Impacts**					
7.1	There is a need for better coordination between the development, delivery, and user communities in the development of products and services.	7, 2, 3, 4, 5		Short	Common	Coordination, Resources, Technology
7.2	A repository of decision-support tools is needed that provides a consistent mechanism of access, documentation, delivery, training, feedback, and expert help.	7, 5		Short/Long	Common	Coordination, Resources, Technology
7.3	Users need more smoke management decision-support tools.	7, 3, 2, 5	Urgent	Long	Unique	Coordination, Data, Resources, Science
FA 8	**Funding and Human Resources (Crosscutting)**					
8.1	Program resources are needed to meet the fire community's need for a real-time 4D characterization of the atmosphere and Earth's surface.	8, 1	Urgent	Long	Common	Coordination, Data, Management, Resources, Science, Technology
8.2	Program resources are needed for improved smoke forecasts (more training, better models, and improved smoke product dissemination) to link traditional fire weather disciplines with newly emergent air quality requirements.	8, 1, 2, 3, 4, 5		Long	Unique	Coordination, Data, Processes, Resources, Science
FA 9	**Socioeconomic Factors**					
9.1	The fire community needs to tap into state-of-the-art socioeconomic tools to reach out to the public to better inform and educate them on the importance of understanding, mitigating, and preparing for wildland fire.	9, 2, 6		Short/Long	Unique	Coordination, Resources, Science

Introduction

Wildland Fire: A Growing Hazard with a Growing Cost

Over the past few years, the wildland fire season has continued nonstop around the year and around all regions of the United States. Factors that have contributed to larger, costlier wildfires include an abundance of accumulated biomass in forests, rangelands, and even urban green space; recurring drought conditions in ecosystems naturally prone to wildfire; and encroaching urbanization. Urbanization increases both the risk of non-natural fire starts and the risks to lives and property of any wildfires, however started. As Figure 1 illustrates, the trend line for acres burned by wildland fires is up more than 100 percent since the mid-1980s. In 2006, there were 21 percent more fires and 57 percent more acres burned than occurred on average during the preceding 10 years. Both 2005 and 2006 have been record-setting years for the number of acres burned.

For the purposes of this needs assessment, the terms "wildfire," "prescribed fire," "wildland fire," and "wildland fire use" (WFU) are used with the following technical definitions, courtesy of the National Wildfire Coordinating Group

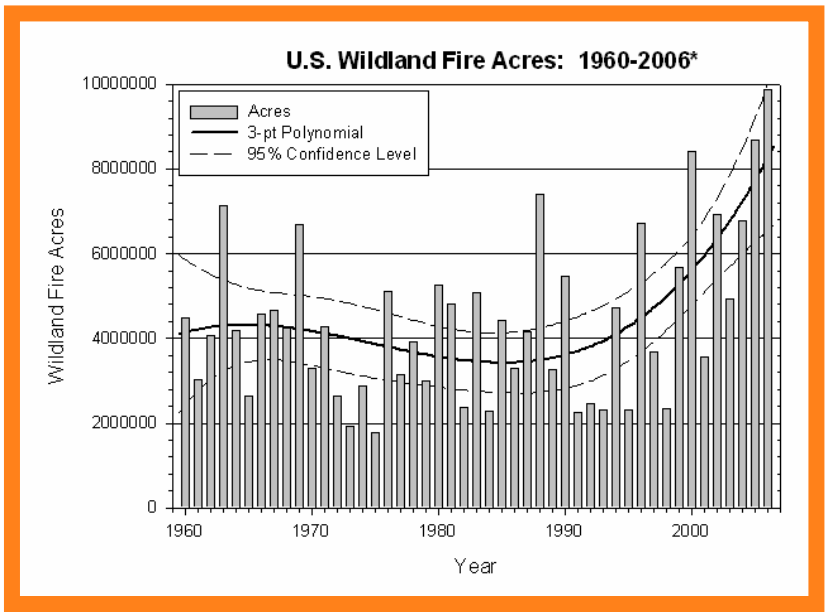


Figure 1. Annual data and trend analysis for U.S. wildland fire acreage, as documented by the National Climatic Data Center.

Wildfire: An unplanned, unwanted wildland fire including unauthorized human-caused fires, escaped wildland fire use events, escaped prescribed fire projects, and all other wildland fires where the objective is to put the fire out.

Prescribed fire: Any fire ignited by management actions to meet specific objectives. A written, approved prescribed fire plan must exist, and requirements under the National Environmental Policy Act (NEPA), as applicable, must be met prior to ignition.

Wildland fire: Any non-structure fire that occurs in the wildland. Three distinct types of wildland fire have been defined and include wildfire, wildland fire use, and prescribed fire.

Wildland fire use: The application of the appropriate management response to naturally-ignited wildland fires to accomplish specific resource management objectives in pre-defined designated areas outlined in Fire Management Plans. Operational management is described in the Wildland Fire Implementation Plan (WFIP).

The costs in lives and economic losses from wildland fires are growing as populated areas and at-risk wildland become increasingly intertwined. In 2003, wildfires in Southern California claimed 22 lives, destroyed 3,600 homes, burned 740,000 acres of land, and caused over $2 billion in property damage. During just the first months of 2006, wildfires in Texas claimed 11 lives, destroyed 440 homes, and burned over 5 million acres. A single fire in Esperanza California, which burned from October 26 to November 4, 2006, claimed the lives of five firefighters and injured 17 others. The property damage included 40,200 acres burned, 34 homes and 20 outbuildings destroyed, with known costs of $9.9 million as of November 1, 2006. Fighting that one wildland fire required the efforts of 1,587 fire personnel.

To manage and suppress wildland fires effectively, fire managers need timely, accurate, and detailed fire weather and climate information. A number of Federal agencies, including but not limited to the National Weather Service in the National Oceanic and Atmospheric Administration (NOAA/NWS), the U.S. Forest Service in the Department of Agriculture, and the Department of the Interior, have responsibilities related to wildland fire management, wildland fire weather, or both. The combined Federal budget for activities related to wildland fire, including fire suppression, preparedness, fuels management, and other activities—now runs at about $2.7 billion annually. This amount does not include the contribution to fire weather forecasting and warning by NOAA/NWS.

Role of the OFCM in Wildland Fire Weather

In 2001, the Interagency Federal Wildland Fire Policy Review Working Group, at the direction of the Secretaries of the Interior and Agriculture, reviewed the *1995 Federal Wildland Fire Management Policy & Program Review* and its implementation. One of the review's recommendations was: "A national plan should be developed that articulates the weather products, standards, and services needed to support the entire spectrum of wildland fire responses, and the best means of meeting these requirements." The review further stated that "the OFCM (Office of the Federal Coordinator for Meteorological Services and Supporting Research) is uniquely qualified to develop such a plan."

Furthermore, in June 2005, the National Science and Technology Council Subcommittee on Disaster Reduction published their "Grand Challenges for Disaster Reduction." In this report, they cited the need for improved wildland fire hazard assessment methods and for more research on wildland fire safe practices to protect communities from the damaging effects of wildland fires.

On June 14, 2005, the Western Governors' Association (WGA) approved Policy Resolution 05-04: National Wildland Fire Weather Program. This resolution called for better coordination of existing research programs in fire weather, as well as additional research, to improve decisions support for those charged with protecting the public and the nation's natural resources from wildland fire threats. It noted the lack of integration of observing stations such as Remote Automated Weather Stations (RAWS) into a comprehensive observing strategy and called for a strengthened joint interagency effort, encompassing all Federal and non-Federal stakeholders, to transfer new digital weather information and technology into operational fire management decision-making and planning. The full text of this seminal resolution is reproduced as appendix A to this report.

Of direct relevance to the subject of this report is paragraph B.4 of Policy Resolution 05-04:

> *The Western Governors urge NOAA to: …*
>
> - *Complete a National Needs Assessment Report, by NOAA's Office of the Federal Coordinator for Meteorology, of federal, state and local fire managers needs for weather information in their wildfire and prescribed fire decision making processes and a framework to meet those needs by the NWS and Predictive Services.*

This request from the Western Governors led directly to the National Wildland Fire Weather Needs Assessment, whose results are summarized here. Shortly after the WGA's meeting, the NOAA Assistant Administrator for Weather Services contacted the Federal Coordinator and solicited help in conducting a National Needs Assessment.

The OFCM operates with policy guidance from the Federal Committee for Meteorological Services and Supporting Research (FCMSSR). FCMSSR is chaired by the Under Secretary of Commerce for Oceans and Atmosphere/NOAA Administrator. The members of the FCMSSR are senior policy executives from the Federal agencies with meteorological programs. The Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR), which is chaired by the Federal Coordinator, is the primary program management body of the Federal coordinating structure. ICMSSR provides advice to OFCM, implements policies set by the FCMSSR, and oversees the committees and working groups established for specific areas and projects within the Federal coordinating structure. On November 18, 2005, a meeting of the ICMSSR addressed the request from WGA and approved the following action item:

> ***ACTION ITEM 2005-1.1: National Wildland Fire Needs Assessment.*** ICMSSR concurred that OFCM should move forward to form a Joint Action Group (JAG) under the Committee for Environmental Services, Operations, and Research Needs (CESORN), to review the needs and requirements for wildland fire weather information, to include identifying organizational responsibilities and addressing the following issues: data collection, fire weather research, weather forecast services, data assimilation, air quality, information dissemination, education and outreach, and user response.

In response to this action item, the Federal Coordinator established the Joint Action Group for National Weather Needs Assessment (JAG/NWFWNA) to undertake a needs assessment, covering the range of stakeholders in the national wildland fire weather community, for weather and climate information in wildland fire decisionmaking. The JAG/NWFWNA was assigned two primary goals:

1. Conduct a comprehensive review and assessment of weather and climate needs of providers and users in their wildland fire and fuels management activities.
2. Assess the capabilities of the provider and research agencies to ensure that needed weather and climate information is available to fire and air quality managers and other users.

In addition to Federal stakeholder agencies (table 2), which includes both users and providers of wildland fire weather information, there were many non-Federal stakeholders to include in the assessment process, such as the following (representative but not exhaustive) list:

- International Association of Fire Chiefs

Table 2. Federal Agency Stakeholders in the Wildland Fire Weather Community

Department of Commerce	**Department of Transportation**
National Institute of Standards and Technology	Federal Aviation Administration
National Oceanic and Atmospheric Administration	Federal Highway Administration
Department of Defense	Federal Railroad Administration
All service components	Federal Transit Administration
National Guard/Reserve	**Environmental Protection Agency**
U.S. Army Corps of Engineers	**Health and Human Services**
Department of Energy	Centers for Disease Control and Prevention
Department of Homeland Security	**National Aeronautics and Space Administration**
Federal Emergency Management Agency	**National Science Foundation**
U.S. Fire Administration	**U.S. Department of Agriculture**
Department of the Interior	Forest Service
Bureau of Indian Affairs	Natural Resource Conservation Service
Bureau of Land Management	
Bureau of Reclamation	
National Park Service	
U.S. Fish and Wildlife Service	
U.S. Geological Survey	

- Intertribal Timber Council
- National Association of Counties
- National Association of State Foresters
- National Fire Protection Association
- Nongovernmental organizations (e.g., The Nature Conservancy)
- The State and Territorial Air Pollution Program Administrators and the Association of Local Air Pollution Control Officials
- Western Governors' Association
- Western States Air Resources Council

The National Wildland Fire Weather Needs Assessment

This document is a summary of the results from the wildland fire weather needs assessment conducted during 2006–2007 by the JAG/NWFWNA (hereafter referenced as the JAG). The JAG performed the following information-gathering and analysis activities as part of the needs assessment.

- Spring/Summer 2006. Mini-workshops with stakeholder representatives were held to frame overall needs and issues.
- Fall 2006. A special session at the 2006 San Diego Fire Congress allowed for increased feedback on major needs of the community.
- Winter 2006. OFCM staff worked with the JAG to canvass the Federal agency community, while WGA reached out to state, tribal, and local fire weather users.

- Spring 2007. The JAG analyzed the information received from 745 Federal, state, tribal, and local fire weather users to derive the fire weather needs as stated in this document.

The JAG was charged with addressing nine functional areas of wildland fire weather:

- Data collection, integrity, processing and archival
- Fire weather research and development
- Forecast Products and Services
- Modeling, prediction, and data assimilation
- Information dissemination and technologies
- Education, training, outreach, partnering, and collaboration
- User response, decision support, and resulting user impacts
- Funding and human resources (crosscutting)
- Socioeconomic impacts

The information-gathering processes noted above asked those who provided input to consider and comment on their needs in each of these functional areas. Each functional area defines requirements and standards for the functions within that area's scope that are necessary to support sound fire management decisions for planning, preparedness, and incidents; and prescribed fire management during wildland fires. Sound fire management decisions can be either tactical or strategic in scope. More specifically, they can include any of the following considerations:

1. Proactive resource allocations
2. Adjusting daily-to-seasonal staffing and preparedness levels
3. Managing smoke, its impact on air quality, and its effect on public health and safety
4. Assuring the protection of the lives of firefighters and the public
4. Increasing public awareness

In this report, the JAG has organized the needs statements according to the functional area of primary importance to that need, although many of the needs are relevant to several functional areas.

On May 31, 2007, the ICMSSR approved of this needs summary along with OFCM plans for development of a framework to meet the needs. Following ICMSSR coordination, the Federal Coordinator briefed the WGA on June 11, 2007. At that meeting, the WGA voiced their approval and continued support for this summary needs evaluation and for the overall assessment effort. The governors remain firmly supportive of the OFCM JAG/NWFWNA effort and are committed to ensuring effective and efficient weather support to fire managers.

Functional Area 1
Data Collection, Integrity, Processing, and Archival

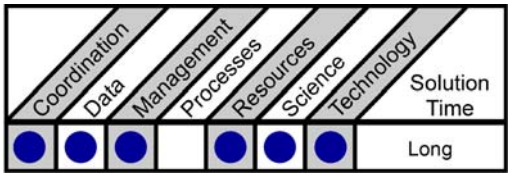
This functional area includes requirements and standards for the density, collection frequency, consistency, timeliness, and archiving of weather data used to support: (1) fire management activities including planning, preparedness, wildfire, wildland fire use, prescribed fire, and air quality applications; (2) basic and applied research; and (3) the integrity of real-time observations and the long term climate record. It documents and recommends requirements and standards for both surface and upper air observations (taken either in situ or remotely). Functional Area 1 addresses the utility to users of a robust set of three-dimensional data for operational and research activities. Other topics in this functional area include the following:

- Required and desired data elements
- Current observation sources and techniques used to support needs related to fire weather
- Who uses each of the data sets and why they need it
- Opportunities for improvement in how data are collected, processed, archived, and delivered
- Existing inefficiencies and barriers (e.g., duplication of resources/effort, cumbersome procedures) with regard to collecting, processing, delivery, and archiving data
- Risks associated with data availability (e.g., interagency dependencies, single points of failure and insufficiencies, uncoordinated technological changes and data standards), data quality, and quality assurance

The JAG analysis of user input for this functional area defined two major needs: one for a comprehensive observing system building on current capabilities and the second focusing on a set of nationwide data standards to ensure that all observing data relevant to fire weather needs can be integrated and made accessible to the fire weather community. The first of these major needs is further specified in terms of four subneeds (1.1a–1.1d).

1.1 Improvements in data management are needed to establish a comprehensive, nationally beneficial observing system to meet the needs of wildland fire weather users.

1.1.a A strategy for a complete, real-time, observationally based, gridded characterization of the current atmosphere needs to be developed and implemented based on an integrated set of all available in situ and remotely sensed environmental data.

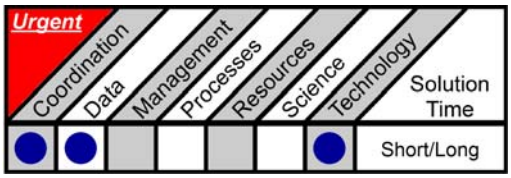


Fire weather users need an accurate and timely understanding of the present state of the atmosphere and earth surface as they evaluate and mitigate fire potential, as they respond to fire events, and as they restore areas damaged by fires. An example of the kind of characterization needed is the Four-Dimensional (4D) Data Cube concept planned for the U.S. Air Traffic/NexGen system, which seeks to provide a continually updated, authoritative picture of the atmosphere. This 4D Data Cube encompasses all three spatial dimensions along with time, represented as forecast interval. As such, the data cube is continually updated to represent the present and future states of the atmosphere throughout a forecast duration. Integrating fire weather needs into a similar system—or into the developing 4D Data Cube system—would allow users to make informed decisions for any point in space, regardless of the observational or numerically modeled origins of the data representing conditions at that point over time.

To achieve this objective, a complete integrated observing sensing strategy needs to be developed and implemented. This strategy needs to include detailed information on all observation sensor types and data elements, accounting for in situ data and remotely sensed data, to ensure a complete, integrated characterization of the atmosphere is achieved. This integrated system needs to consider standard, fielded surface systems, such as the NWS automated surface observing systems (ASOS), and the remote automated weather system (RAWS), which are commonly used by the fire weather community. Existing and planned mesonets need to also be included. Additionally, new technologies need to be leveraged, to include remote sensing platforms, radars (e.g., the multifunction phased array radar technology), atmospheric profilers, and aerial surveillance/sensing systems. This integrated system needs to make use of all fire weather data elements, especially those at the surface and within the atmospheric boundary layer. Additionally, an interagency approach is needed to ensure that all suppliers, users, and beneficiaries work together to ensure consistent funding, development, implementation, and use of available systems.

These data need to be made available to users in both high- and low-bandwidth options and in various formats such standard graphics, GIS formats, PDA-supported formats, and text formats. The 4D data system needs to make full use of satellite and other remotely-sensed data. Additionally, these data need to be made available openly to all levels of government.

1.1.b A centralized means of reliably retrieving validated observational data is needed.



Until a real-time, observationally based, gridded characterization of the current atmosphere is available, the fire community needs robust access to timely and accurate observational data.

Effective management of current and evolving operational data sets is critical to providing these data to the community. Data must be available from a centralized access point. Data available from this access point needs to include metadata information regarding data location, quality, and accuracy. This access point must allow users to quickly obtain data year-round and from any location, in either real-time or archived mode. Metadata must be universally provided to facilitate ease of information "tagging" and application.

Coordination must be accomplished with the fire weather modeling community to ensure data are provided in a manner consistent with needs associated with rapidly evolving fire weather and fire spread modeling needs.

Data must be made available in GIS format to ensure ease of display in any format the user demands and with any spatial resolution. Data must support high- and low-resolution needs in both time and space.

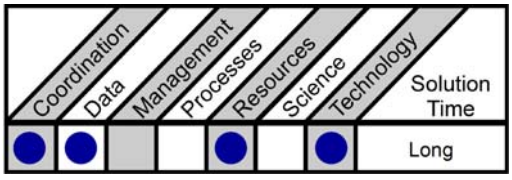
Robust and redundant data archiving and retrieval are needed to ensure rapid access and to prevent data access outages despite power or communications failures.

This system needs to be able to keep pace with changes in technology. Sensor placement and data collection need to be done with the intent of maximizing the long-term utility of the data for climatological applications.

Data validation is needed to ensure the integrity of data sets containing that data. Validation includes an evaluation of the accuracy and reliability of the data, given past performance by that station with respect to maintenance and other issues. Validation information needs to be included in a metadata field to allow users to make appropriate use of the data.

Fire weather users also need to be better informed about alternative data sources, to include remotely sensed data, sounders, aircraft data, unmanned aerial systems, etc., which would help them better understand current environmental conditions and forecast future conditions. For example, the user community expressed a desire for more frequent NWS upper air soundings in order to better evaluate fire threat conditions. However, similar observed (and forecast) information is available from other sources which could readily help characterize the fire threat conditions needed by fire weather users with more frequent updates than the present NWS upper air sounding system. A centralized data system would better enable users to access all available data.

1.1.c A complete suite of deployable and non-deployable sensors must be well maintained and fully integrated into a national network for common data availability.



Users need rapidly deployable sensors, which can be used to augment the existing observing network during wildland fire events and to meet additional needs of local agencies. Sensors need to

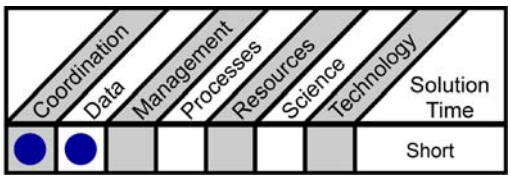
be easily deployable and should be readily integrated into the national observing network to allow users to access data from these sensors in real time, via their standard data sets.

Manual data entry should be eliminated as much as possible in favor of automated, standardized ingest systems. All observing sensors should be fully automated such that their data automatically flow to a centralized repository without manual intervention.

Sensors need to be properly maintained to national standards. All sensors must be properly replaced as needed to ensure consistency of data quality.

Stations should, to the extent possible given the in situ conditions, report year-round in order to support operational and climatological use.

1.1.d The comprehensive, prioritized list of needed observed and predictive fire weather data elements developed from this assessment should be refined and validated.



The following list of data elements needs to be refined and validated, based on the role of the data in generating the products and services most important to wildland fire users. In presenting this preliminary list, the JAG emphasizes that some environment parameters may not seem important to wildland fire users, yet they may be essential for accurate numerical modeling on which the products and services critical to operational wildland fire users are based. In this preliminary list, data elements are prioritized by group (e.g., Highest Priority) but are not in priority order within a group.

Highest Priority

- 20-ft. wind speed measurements. Users requested greater spatial and temporal resolution in the data made available to them.
- 20 ft wind direction
- 20 ft hourly wind peak
- Lightning data. Many users indicated they require much more lightning data than is currently available.
- Precipitation data (amount and intensity). Users need greater spatial resolution for precipitation data.
- Fuel moisture data. Users desire it at greater spatial and temporal resolution.
- Surface air temperature
- Relative humidity
- Mixing height

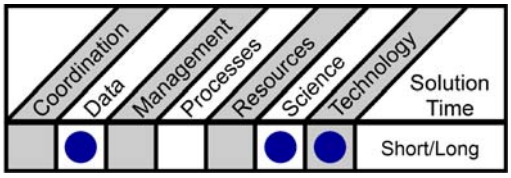
Moderate Priority

- Upper air winds
- Fuel temperature
- Cloud cover percentage
- 2.5 micron particulate matter/smoke concentration. Users believed this data element to be the one least available and/or accurate.
- Lapse rate

Lesser Priority

- Solar radiation
- Soil moisture
- Barometric pressure

1.2 All national weather station standards (to include those used by other agencies and NFDRS standards) should be reevaluated to ensure proper integration of all pertinent weather station data (to include portable weather stations) for use by the wildland fire community.



The specific point of this need statement is that, if data standards exist that can be established as universally important to the wildland fire community, they should be recommended as national standards for all meteorological measurement sites—at least for those sites in non-urban areas. Inclusion of data standards important to wildland fire weather into them national standards for all sites would improve wildland fire support across the Nation.

Functional Area 2
Fire Weather Research and Development

Fire Weather research and development (R&D) includes all basic and applied research and development (applications and technology) relating to wildland fire. Examples of important components of fire weather R&D include: fire meteorology, fire danger, fire behavior, and fuels condition. User input for this area will help to delineate and prioritize R&D requirements. However, R&D requirements and priorities will also depend on expert judgment about the best ways to address other functional areas where users have firsthand knowledge of what will help them—particularly the Products and Services needs (Functional Area 3). The following topics were covered by user input in this functional area:

- Identification of current research programs, projects, and initiatives viewed by users as relevant to wildland fire weather, covering all the scientific disciplines that may be relevant to advances in products and services for the wildland fire community
- Users' assessments of knowledge gaps (and complementary areas of knowledge) in disciplines relevant to wildland fire weather
- The spectrum of users' needs and requirements for fire weather R&D
- Existing and potential research capabilities pertaining to this functional area (among Federal, state, local, private, and academic research entities), including indications of redundant or overlapping R&D activities that do not appear coordinated
- Potential partnerships among R&D entities, including partnerships across two or more sectors (Federal, state, local, academic, or private)
- Transition from R&D to operations and implementation of new science in decision-making)

The JAG analysis of user input for Functional Area 2 produced four major needs. The first of these, divided into three subneeds, covers R&D *topics* of interest to the wildland fire weather community, particularly on topics where they perceive a lack of the underlying science and understanding needed to help them in their work. The other three issues (2.2 through 2.4) are more process-related; they address: how the user community gets research results, how R&D is transitioned into operations, and users' interest in being more effectively integrated into the R&D effort early enough to provide effective feedback on operational usefulness.

2.1 The fire community needs a better understanding of the physical processes associated with fire potential, fire combustion, wildland fire smoke, and climate change/climate variability.

Dynamics between the atmosphere and fires need further study and research, leading to better understanding of the drivers of fire behavior. Researchers need to understand fire danger and behavior based on physics, not just the algorithms devised by empirical investigations during the 1960's. Existing fire danger indices, such as the Haines index, need more research emphasis. New management methods need to be developed that are based on this improved understanding.
Users indicated that many research topics are of high importance, but also indicated that in many cases, much more information is needed regarding research efforts.

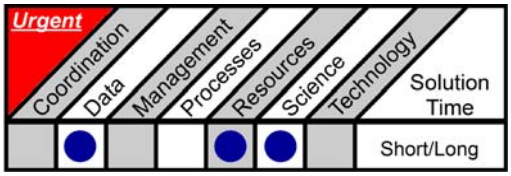
Among the research topics that users noted as very important were the following:

- Fire weather
- Fire behavior
- Protecting people
- Fire danger
- Wind gusts, measurements, and impacts
- Atmospheric stability (new Haines index)
- Smoke density/pollutant concentration
- Smoke trajectories
- Protecting structures
- Duff moisture (impact of precipitation and weather on fire behavior)
- Fire and climate change
- Fuel treatments impacts
- Remote sensing/satellites
- Fire climatology
- Fire ecosystem impacts
- Mountainous wind patterns
- Drought modeling
- Fire ecology
- Lightning climatology
- Fire detection

Users indicated that the following research topics are of moderate importance: dry slots and their impact on fire, fire economics, and fire social science issues.

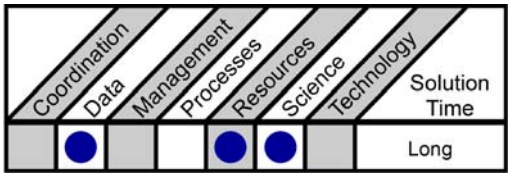
Users indicated that information on research activities and results are especially lacking for the following topics: protecting people; wind gusts, measurements, and impacts; smoke density/ pollutant concentrations; smoke trajectories; Duff moisture (impact of precipitation and weather on fire behavior); fire climate and change; mountainous wind patterns; dry slots and their impact on fire; and fire economics.

2.1.a The interaction between fire potential, fire combustion, and atmosphere needs to be better understood and modeled.



Regional weather predictions, especially those from gridded models, need to be linked to fire danger. The predictive skill of fire behavior models needs to be improved (e.g., fire intensity, flame length, heat release, rate of spread, generation of convective columns, other). The physical understanding of, and predictive skills for, the transitions from moderate- to high-intensity fires need to be improved.

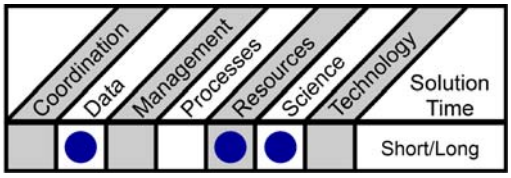
2.1.b A better understanding of wildland fire smoke is needed, and smoke prediction tools need to be refined and perfected.



Although wildland fire smoke was not ranked as the highest ranked need, the two survey questions about smoke highlighted that it is the wildland fire condition for which there is the largest perceived gaps between the need for understanding and prediction, the amount of work being done, and the quality of the work being delivered. Based on the user input received, the amount of work being done in this area should be increased and its perceived quality should be improved. Users' comments evidenced concerns about how results are displayed, the coarseness of model results (for FS Bluesky), particulates, and atmospheric transformations. One issue not discussed by respondents but of known importance is gathering research data sets to validate wildland smoke models, a topic that is perhaps reflected in the gap between users' expressed needs and their perception of the quality of current products.

Users see wildland fire smoke as a great challenge for which the R&D community has not provided enough sound science. They want complex, realistic models that produce reliable predictions of ground-level smoke at many spatial scales (near the fire, at meso and regional scales, at the continental scale). They want reliable smoke emissions inventories created without having to add much information about fires manually—perhaps using remote sensing as a fire information/data source. Users want smoke models for regulatory purposes (permitting), planning, and public information, but they fear existing models are not sufficiently validated.

2.1.c Wildland fire and climate change/climate variability is an issue of high concern, for which more scientific understanding is a priority.

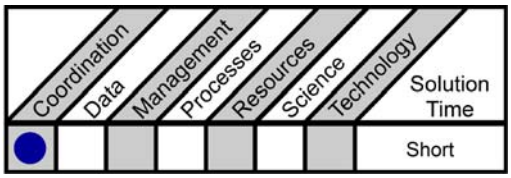


Another area with a large gap between users' expressed need and research is in the relation of climate and climate variability to wildland fire. Climate change effects on fire season length and severity is an issue that users recognize as needing more objective science. Users also wish to know how variability in fire weather patterns may be altered under a changing climate. Naturally, this area

is closely linked with drought modeling and fire climatology themes, and it may be appropriate to address them together, under a common heading such as "Climate Variability and Fire."

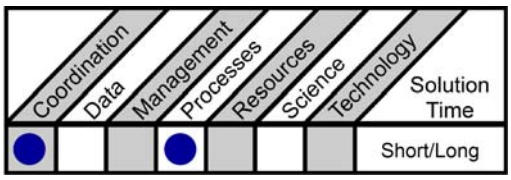
However, these topics and issues are categorized, and there is an identified need to address variations in climate and their influence on fire from a landscape perspective. There also exists a significant gap between this need and users' perception of the quantity and quality of research being done. Some of the perception about quality may come from incomplete or non-existent information transfer from product developers to all levels of the fire management community. Reliable research information on climate change and fire needs to be transmitted to users in a manner that can be applied to the job (representative user comments: "no hand-wringing," "something useful"). Remote-sensing for climate variability influences to fire conditions, especially for fuels state, was also viewed as a research need. Carbon sequestration is recognized as an issue for fire management, but it is not seen as a priority research need in wildland fire management.

2.2. Users need easier and more centralized access to information on research initiatives, efforts, and successes.



Nontraditional methods of delivering science results are needed to get this information to the fire community. Traditional science delivery methods such as journal articles are useful, but other methods need to be developed to support these traditional methods. For example, users want research information shared via the World-Wide Web (Internet). Additionally, personal meetings between users and researchers were considered one of the best science delivery methods.

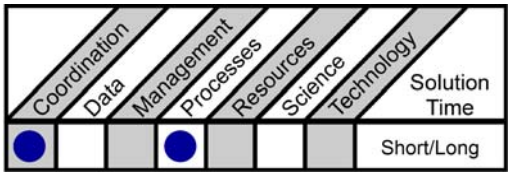
2.3 Mature research needs to be integrated systematically into an operational environment for routine use by the fire community.



Wildland fire research agencies and operational agencies need to collaborate and cooperate together to develop a process to systematically transition research efforts into operations. This effort also needs to allow for operational needs to feed into the research community so that future research efforts can be based upon user needs.

This area was also identified by the WGA as one in which greater communication and problem-solving between science and fire weather operations is needed to provide for improved decision support to protect the public and vital natural resources.

2.4 Users need to be integrated into research and development efforts to allow for effective feedback on operational usefulness.



Users need to be included in the direction and execution of research, priority setting by research organizations, and research budget decisions. Users and researchers would benefit from shared access to interim products, if such products can be presented with appropriate information of accuracy and reliability of results.

Functional Area 3
Forecast Products and Services

This functional area includes weather and climate forecast product or services necessary to support sound fire management decisions for planning, preparedness, and incident management of wildland fire events. It also includes requirements and standards for these products and services, with special attention to differences in how forecast information is used geographically and by different user groups.

The following topics were covered in this area of user input to the needs analysis:

- Required and desired forecast elements
- Current operational forecast products and services used to support the responding user's needs related to fire weather
- Who uses the current operational products and services in the responding user's organization and why they need it
- Critical values used in decision processes at the user organization
- Experimental or research products available at the user's organization how accepted products are transitioned into operations
- Potential areas for improving forecasts, not elsewhere covered
- The user's perception of opportunities where increased coordination and collaboration (e.g., coordination calls, operating plans) could improve products or services

As one might expect, user input on fire weather products and services had the greatest specificity and detail among the eight functional areas. The JAG analysis of this input defined four major needs, three of which have multiple subneeds to further capture the information provided by the users. The first major need is for products and services tailored to the functions of particular user categories or for users at different levels in the national/regional/local hierarchy. The second major need concerns training and reference materials to get the most benefit from products and services. Whereas need 3.1 focuses on tailoring existing products to the (type of) user, need 3.3 addresses general ways in which products and services need improvement. Need 3.4 focuses on ways to improve the utility of fire weather forecasters to the wildland fire community they serve.

3.1 Improved forecast products and services are needed across duty functions and at each level of government to meet the widely varying needs of fire operators and managers.

Products need to be made available in GIS format, and they need to be in gridded digital format, available in graphic display as appropriate, and with uncertainty information (probabilistic confidence limits) as applicable.

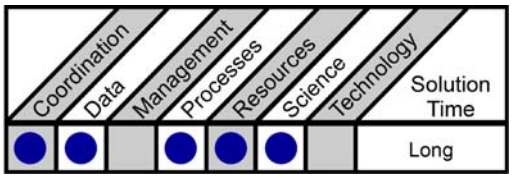
Users considered the following products to be very important: NWS fire weather forecasts; red flag warnings; fire weather watches; spot forecasts; fire danger forecasts; NFDRS forecasts; 7-day fire significant potential; smoke dispersion / ventilation / transport forecasts; fuel moisture forecasts; satellite imagery (infrared and water vapor); seasonal weather outlook; and drought forecasts.

Users considered the following products to be moderately important: monthly fire outlooks, smoke concentration forecasts, seasonal fire outlooks, mountain wind patterns, and stagnation advisories.

Users considered two products to be of particularly poor accuracy and availability: smoke concentration forecasts and smoke dispersion/ventilation/transport forecasts.

Users desire better use of radio broadcasts to alert them concerning weather conditions that affect wildland fires. Suggestions include descriptions of which parameters are important for the current fire forecast conditions, along with the time of day for each of these conditions.

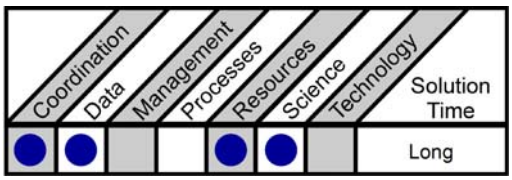
3.1.a Managers at each level of government need tailored products and tools for their unique duties and responsibilities; these products need to be made available to the entire community for greater use and awareness.



Products to be considered are varied, but each level of user needs a basic set that identifies fire threat, primary environmental conditions (weather, fuels, etc.). Products need to be tailored and appropriately emphasized (made available) for various uses. For example, strategic-level products are great for strategic planning, but need to be easy to find and clearly distinguishable from tactical-level products.

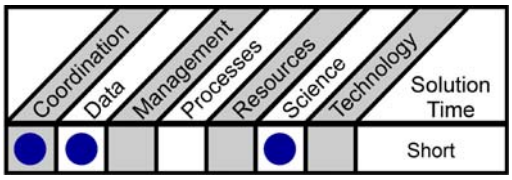
One aspect of this is the need for NWS Spot Forecasts, or similar products, to be made available to state and local government in the same way that they are made available to public safety officials, so that they can effectively perform their roles and responsibilities. Spot Forecasts are an important tool, highly valued by large segments of the fire community, but a broader approach is needed regarding their issuance and dissemination.

3.1.b Information on forecast product accuracy should be made available to users.



Users need information on forecast accuracy in order to make informed decisions about their use of current forecasts. Forecast production centers routinely produce and track this information in order to monitor and improve their technical proficiency. This information needs to be made available to the user community, in easy-to-understand formats, so the community can better understand product accuracy along with product accuracy change over time.

3.1.c Users need more detailed information regarding long-term forecasts and climate outlooks.

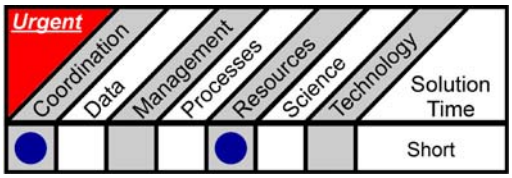


Users' decisions are based upon an understanding of various climatic elements and their impacts on wildland fire needs. It is therefore important that climate-related products explain what the predominant meteorological drivers are for the end results.

3.2 Users need improved training and reference materials that facilitate proper interpretation and use of forecast products, as well as improved access to this material.

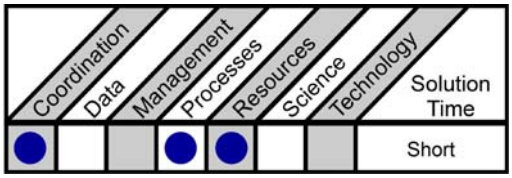
Many users expressed concerns regarding the appropriate use of various products and services. Lack of references and proper training result in confusion as to which products are best for certain circumstances. Additionally, this extends to correct use of the various products as well. Underlying assumptions and information on product usage would greatly benefit the community.

3.2.a Existing training and reference material for products and services need to be made readily available to all interested users.



Users need improved access to online training and reference material to enable them to make appropriate use of all available products and services. These materials need to describe underlying assumptions (forecast-based and/or model-based) that went into the development of the various products. Furthermore, these references should include information on product timeliness, which also includes information on the timeliness of the data that went into the product. All of this will better enable users to appropriately use and adapt forecasts, based upon the most current environmental information, to meet their needs.

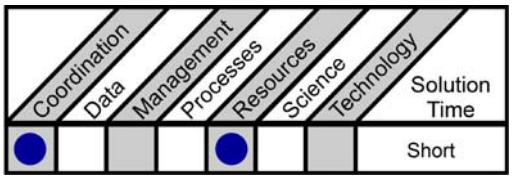
3.2.b Training and reference material for products and services need to be improved and expanded, based upon proven best practices from the field.



Training and reference materials should provide simple explanations concerning product applicability and use. Clear explanations of how parameters are depicted, couched in terms understood by the target user community, are essential. This information should include as much information as possible about product strengths and weaknesses, and in what type of conditions the product is ideal for. Furthermore, this should include detailed underlying assumptions that went into the development of the product so that users would know when the product is not well-suited for its current application.

These training and references need to also include information on standard production timelines so that users know when the products should be available and what data (observed and/or model), with appropriate data cut-off times went into the development of it.

3.2.c Training and information on interpretation and use should accompany all products and services, especially as new ones are implemented.

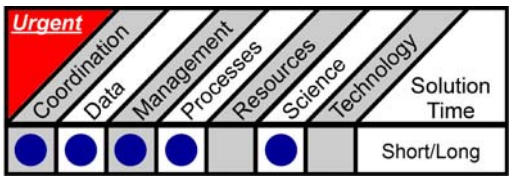


The community needs more information regarding how products are designed to be used. This includes a need for information regarding how products are developed and what elements are used or considered when developing a product. For example, if a wildland fire threat product only includes certain types of fuels, the community needs to know that, so they can factor that information into their decisionmaking processes. This is especially important for the community in situations where one product is not well suited for that situation but another product is.

3.3 User feedback indicates that many useful products currently exist, but improvements are needed across a broad spectrum.

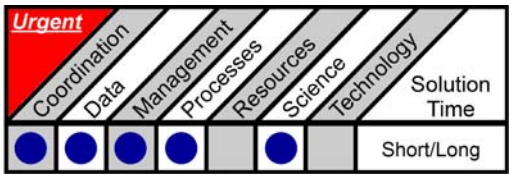
The community is pleased with the tremendous increase in products and services in recent years. However, users expressed concern regarding the accuracy of certain products in various situations.

3.3.a Users value the availability and accuracy of NWS Fire Weather Forecasts and articulated the need for greater accuracy where possible.



The entire user community considers the NWS Fire Weather Forecasts to be very important. At the same time, the community is concerned about the accuracy of these forecasts. However, products should be better tailored to user needs, and their accuracy improved as much as possible.

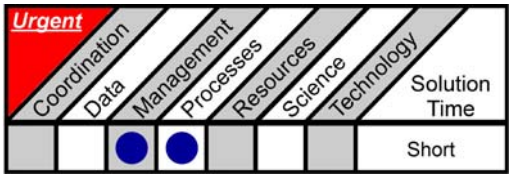
3.3.b Users need statistical information on current accuracy and verification for NWS Fire Weather Forecasts.



Detailed information on key parameters should regularly be made available to the user community. Users already have a sense of the accuracy of NWS Fire Weather Forecasts. However, this sense is largely subjective and based on each fire weather user's own experience. Objective statistical information on product accuracy would serve the entire community because all users would know whether or not these products are well suited for decisions from day to day. This information will

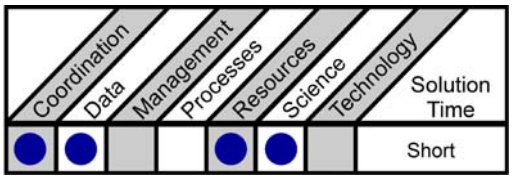
also enable users to become more aware of product improvements as they see objective statistics indicating that products are improving. Furthermore, information on accuracy will encourage user feedback because users will be sensitive to actual (or perceived) weaknesses in forecast accuracy.

3.3.c Users value Red Flag Warnings and articulated the need for fire weather warnings at longer lead times and with the widest possible dissemination.



The entire user community considers Red Flag Warnings to be very important, but respondents repeatedly asked for these types of warnings to include lead times of 2–3 days. However, any changes made to these products need to also be made in such as way that the resulting forecast information clearly explains contributing factors, timing, and terminology. Some users also expressed a need for clarification on what the term "Red Flag Warning" actually implies. Essentially, they seek greater information about what is meant by this type of warning. Congruent with that need, they also seek greater information on fire potential in general, not just when conditions pose enough risk for a warning. Furthermore, these types of products need to be more widely disseminated to the entire community and they need to be made available via low-bandwidth options.

3.3.d There is a specific need for improved smoke dispersion products.

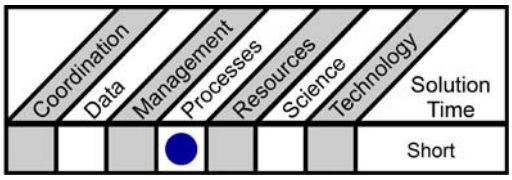


Users were generally disappointed with the information they receive on smoke products. Nearly unanimously they said they do not receive enough of it, nor is it of sufficient quality. Some users reported that they have no source for smoke products. The spatial resolution requested was weighted towards finer spatial resolution—finer than is currently simulated routinely by either air quality models or the underlying meteorological models.

Many users asked for more products to help them understand smoke dispersion potential. This will require much science work to be done to more accurately model smoke dispersion. Additionally, more comprehensive data are needed to help develop smoke dispersion models and to validate results. Furthermore, significant coordination is needed throughout the wildland fire weather community to help users understand what the current state of science can bring into this arena and what limitations exist.

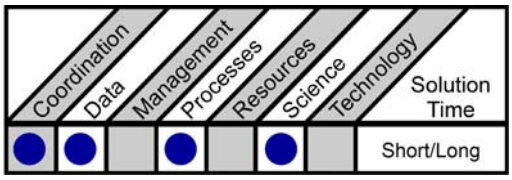
Given the known data and forecast challenges for smoke dispersion products, it is vital that these products be made available in such as way that users are informed as to their accuracy along with a measure of the relative confidence they should ascribe to the results. And, users need detailed references concerning the interpretation of these products and the underlying assumptions that were made as part of their development.

3.3.e Users need NFDRS forecasts for more locations.



Respondents were concerned about availability of NFDRS forecasts, which are currently completely dependent upon availability of NFDRS data. Users need to be made aware of this limitation concerning the availability of NFDRS forecasts. Research is needed to determine whether or not meaningful NFDRS forecasts can be developed from non-NFDRS observation data and/or NWS gridded data. As an extension of this effort, users could also benefit from information on alternatives to NFDRS forecasts, particularly when useful NFDRS data are not readily available for their areas of interest.

3.3.f Users need improved fuel moisture data and forecasts that provide more timely, reliable, and spatially resolved information.

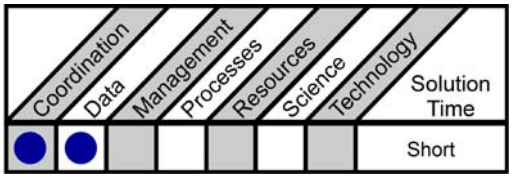


While users stated a need for more of this information, a significant amount of the requested data are already available. Users need to be made more aware of available products.

In addition to the fuel moisture data available, more data on fuels and fuel moisture are needed in order to better forecast moisture conditions.

More research is needed to better understand fuel moisture changes and to better model atmospheric conditions that give rise to fuel moisture changes.

3.3.g Users would benefit from use of forecast upper-level atmospheric parameters and stability conditions.



Fire managers desire information on forecast conditions throughout the day in order to make appropriate decisions concerning wildland fire. These products should be made available to users.

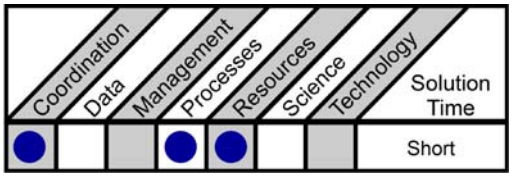
3.4 To help all fire weather forecasters meet the increasing needs of wildland fire managers, a more consistent and standardized set of product requirements is needed.

Fire weather forecaster training would be enhanced by more consistent and wildland fire support products and tools used throughout the community. These tools need to emphasize standardized fire weather thresholds which are critical to the wildland fire community.

Fire weather forecaster training would be enhanced by more standardized product usage availability throughout the community. This would allow more consistent use of products, reduce confusion, and better ensure that products are optimized for their effectiveness.

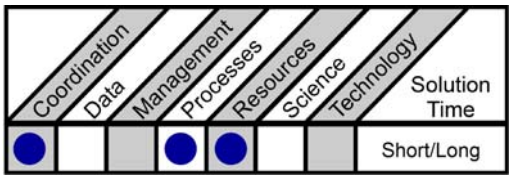
Fire weather forecaster training needs to include localized considerations for varying regions of the country. This effort would be enhanced by the development of local references, made available online, for fire weather forecasters to train on while at home, and in preparation for deployments.

3.4.a Fire weather forecasters need to develop and support standard representations of fuels information along with standard meteorological conditions and fire weather threats.



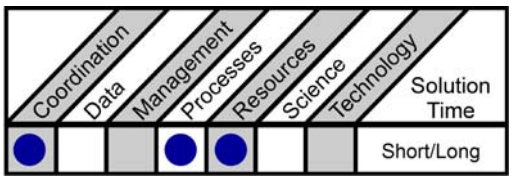
Wildland fire weather users are hindered by non-standard depictions of standard wildland fire weather and fuels data elements. Because many of these elements are common to the entire community, standards are needed. Development of these standards would allow users to quickly and correctly interpret conditions and make accurate decisions. Additionally, this would help the community train new fire weather users allow for improved communication and understanding.

3.4.b Fire weather forecasters need clear depictions of critical and standardized threshold/breakpoint conditions on their standard product suite of analyses, forecasts, and decision-support tools.



Wildland fire weather users need clearer depictions of their weather data and fuels thresholds on charts which are produced for their use. Standard representations of these critical thresholds, in a way that accentuates important information, will better inform users to significant events. This improved communication will better assure time-sensitive decisions are made with correct understanding of the current and forecast conditions.

3.4.c The fire community needs to establish accuracy requirements for fire weather products and services to enable the provider community to focus improvement efforts where most beneficial.



Wildland fire weather producers need to know the accuracy requirements of the fire weather user community. Knowledge of these requirements will enable the forecast community to focus efforts where greater accuracy is most important.

Functional Area 4
Modeling, Prediction, and Data Assimilation

In the context of the NWFWNA, this functional area refers to the numerical tools and data needed to produce fire/atmosphere prediction-related products. It focuses on numerical prediction tools related to fire weather, fire danger, smoke behavior, and/or fire behavior, along with the associated techniques for assimilating data into those tools and displaying the prediction results. The following topics are included in this functional area:

- The spectrum of users' needs and requirements for predictive information
- Users' current modeling platforms, prediction products, data ingestion needs, and data assimilation techniques
- Needed capabilities not currently available and knowledge gaps related to providing those capabilities
- Existing and potential capabilities in the Federal sector
- Potential partnerships that can improve existing predictive products and services or provide new ones to serve unmet user needs

The JAG analysis of user input for this area documents and recommends requirements and capability needs (knowledge gaps) for the wildland fire/atmospheric interface in the following topical areas:

10. Fire weather data
11. Real-time fire planning, mitigation, and suppression
12. Fire danger and behavior
13. Air quality and smoke behavior
14. Climate variability implications for fire severity

The JAG analysis for this functional area defined general research knowledge gaps, identified areas of likely research partnerships, and addressed general guidance on the time and resources that will be needed to fill these gaps. These results are formulated as one major need with four subneeds.

4.1 Fire weather users and the meteorological community require the rapid transfer of fine-scale modeling, coupled fire-atmosphere modeling, and climate modeling advances into operations; emphasizing capabilities, limitations, and current improvement efforts.

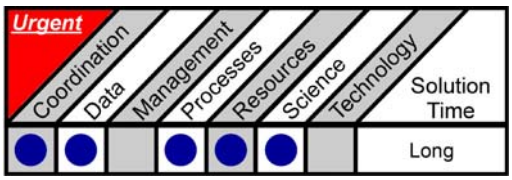
Users indicated that the following model output products are very important**:** wind speed, wind direction, relative humidity, fuel moisture, precipitation (duration and amount), smoke trajectories, fire spread, surface air temperature, inversion/stagnation conditions, mountain wind patterns,

Haines index, fire danger, fire intensity, mixing height, lapse rate, and ground level smoke density/ pollutant concentration.

Users indicated that the following model output products are moderately important: upper air winds, transition to crown fire, cloud cover percentage, fuel temperature, and soil moisture.

Users were especially concerned with the lack of forecast information and accuracy concerning: transition to crown fire, mountain wind patterns, ground-level smoke density/pollutant concentration, lapse rate, inversion/stagnation conditions, fire intensity, mixing height, smoke trajectories, and fire spread.

4.1.a Users overwhelmingly need higher resolution meteorological model fields in complex terrain and the tools and input data to understand fire behavior and smoke dispersion.



Users need more and better wind forecasts, with special emphasis on mountain winds, where the data are of low quality, insufficient, or (in many comments) not available at all. (Some users said they had no source for mountain winds.) The resolution requested was split, but weighted heavily towards finer spatial resolution—considerably finer than is currently run routinely in real time anywhere.

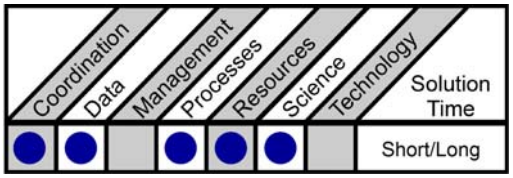
Users unanimously desire and need more and better quality model data on the three fire behavior fields (fire spread, fire intensity, and transition to crown fire). This capability gap reflects the fact that forecast results for these fields are currently either not routinely provided or not uniformly provided (in contrast, to routine, uniform reports of observation data and forecasts for weather elements). Interpretation of specific needs for these fire behavior fields should consider the following caveats:

- Because these fields are not provided routinely or uniformly, no consensus has been developed.
- A variety of usage scenarios is apparent: information for short term, tactical uses (within the day), information for planning the next few days, and strategic planning for the next week or beyond.

Users require access to relative humidity data updated at least hourly.

Additionally, there needs to be a greater focus on more multidisciplinary computer models to improve our ability to simulate the interrelations of fuels, fire, and weather. Furthermore, this should be expanded to include greater simulations of socioeconomic impacts of fires, should they develop, based upon the potential threat to various areas. This effort should also include better modeling of the affects of land management practices to allow for greater understanding of which practices are most effective, in terms of land management, and in terms of socioeconomic protection of life, property, and natural resources.

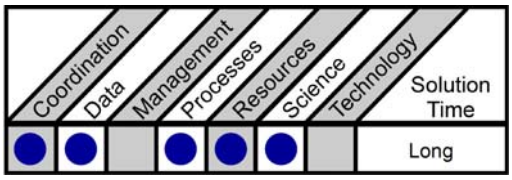
4.1.b Users need model accuracy and confidence information presented to them in an understandable format.



Users must understand that accurate-looking products can have significant error ranges. Model products need to include this information to aid the wildland fire community in using the products appropriately. The need for information on model accuracy and confidence (in the statistical sense of confidence limits) extends to coarse models, fine-scale models, coupled models, and climate models. This need will only increase as finer-resolution model data are made available.

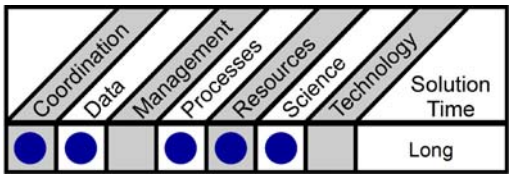
Note that the fields most needed (wind speed and direction and relative humidity) are among the fields with the highest prediction errors according to routine verification procedures for real-time mesoscale modeling. Current verification statistics do not show the predictions for these fields improving with increased model resolution, given the present state of model parameterizations. Nonetheless, improvements are expected as better models are developed.

4.1.c The fire community needs better modeling of fire potential, threat, and impacts associated with climate and climate change.



Users are aware that climate change is impacting their ability to prepare for and mitigate destructive wildland fires. However, there is much uncertainty concerning how climate change will affect various regions of the country and what should be done to prepare appropriately for future changes. Improved modeling of climate change scenarios would enable wildland fire weather users to better understand potential climate impacts so that they can manage and monitor wildland ecology, thereby reducing damaging wildland fires.

4.1.d Model output information needs to be made available in easy-to-use graphics and in high-bandwidth and low-bandwidth formats for use on workstations, PDAs, and via text messaging. Products also need to be available in GIS format.



The wildland fire weather community is adept at using the output from various numerical models to meet their needs. While many users have ready access to high-bandwidth products and services, others are severely limited in their data access points. Production centers must consider the wide range of users and develop products that are well suited for a wide range of customers.

Many users asked that all graphics be made available in GIS formats. They are familiar with this format, and it allows them to overlay fire weather information easily on geographic maps of other significant data fields. Additionally, many users asked that operational data be made available in a low-bandwidth option, to include text and PDA-viewable graphics. These low-bandwidth formats are especially important for products that are valid only for the near term, such as time-critical information needed to manage existing wildland fires or to warn users of fire threat within the next 24 hours.

Functional Area 5
Information Dissemination and Technologies

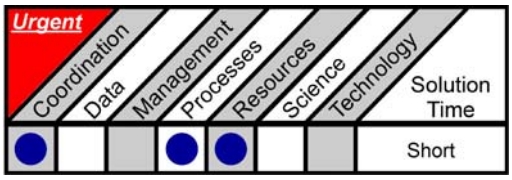
This functional area documents and defines requirements and standards for the dissemination of information and related technologies necessary to support sound fire management decisions. A particular focus of this functional area is the processes required to ***transition current and future technologies to operational status*** in a timely and organized manner. Another focus is on identifying ***opportunities for improving collaboration*** on developing technologies for information dissemination.

The following topics fall within the scope of this functional area:

- Information dissemination elements required or desired by users
- Information dissemination technologies currently used by respondents to support fire weather activities, and identification of which technologies among these are *operational* i.e., approved/accepted as a basis for official/formal decisions, results, etc.)
- Within a respondent's organization, who uses each of the current technologies and why they need it
- Opportunities for improving information dissemination and the development of information dissemination technologies
- Experimental ("trial") technologies being tested or in use by the respondent's organization and how such experimental technologies are transitioned into routine operations (formal "operational" acceptance)
- Opportunities for increased coordination and collaboration (e.g., partnerships within and across Federal, state, local, academic, and commercial sectors) to improve information dissemination, including but not limited to technology development

As in Functional Area 3 for products and services, the functional area for information dissemination and technologies received a great deal of detailed input from the user community. The JAG has defined five major needs based on that input. The JAG judged two of these to be urgent: an Internet presence that provides "one-stop shopping" to facilitate access to products and tools by fire weather uses (Need 5.1) and the related need for robust, real-time access to weather data (Need 5.5)

5.1 A coordinated, "one-stop" fire weather Internet presence is needed to facilitate fire weather user access to pertinent weather data and products for their region of interest.



The fire weather users need to go to one location for authoritative and comprehensive access to products and services. Users need a site with the following features:

- Allows users to easily locate products and services they need to do their jobs
- Includes operational products along with new research, developmental products, and other operational and non-operational tools
- Serves as an authorization/certification of various products and services (products available on the site are marked as either certified for use or for evaluation purposes only)
- Includes information on product accuracy (this feature could be further enhanced by including information on forecast confidence levels)
- Serves as a repository for regional and local information for newcomers and for initial training
- Helps simplify training efforts through greater product standardization and access standardization
- Includes usage metrics to identify high-use products and/or document increased need for certain products
- Provides connections to archived data (e.g.., hyperlinks to data storage sites)
- Offers multiple security levels to control access to data
- Enables leveraging of existing backup capabilities for data and systems and provides load balancing techniques to help ensure continuous (24-hour) data availability

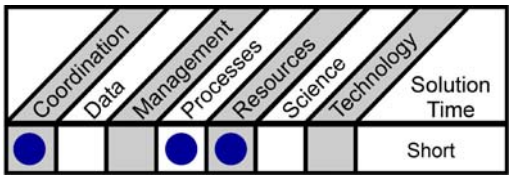
A key point is that this central Internet presence is meant to serve as a easy-to-use gateway to any and all weather data, research, and materials applicable to the community. However, users still strongly desire use of regionally tailored web sites, to facilitate their daily operations. Given the vast amount of available data and products, tailored web sites still fill a crucial need for regional users to quickly obtain operational data for their routine use.

This central Internet presence is meant to provide ready access to all products, services, references, and news information needed by the fire management community and should be a source they routinely check to ensure they are making the most of all the latest information and material.

One benefit of this approach is that it would make the community more aware of the growing number of digital weather databases which are available to the community. These provide a wealth of information, in a format which can be readily tailored for decision-support applications. However, without the wide-scale publicity which can be provided via a single Internet site, many users are unaware of these products or their uses. Additionally, once users become accustomed to

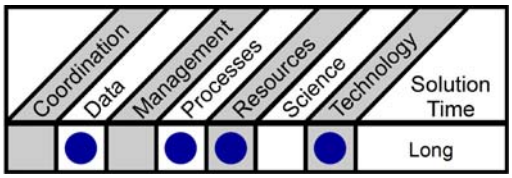
using these types of products, they need a mechanism which allows them to learn of changes and improvements. Again, a single Internet presence can more readily allow for this type of information flow to the entire community.

5.2 A centralized means for collaboration on products and services is needed.



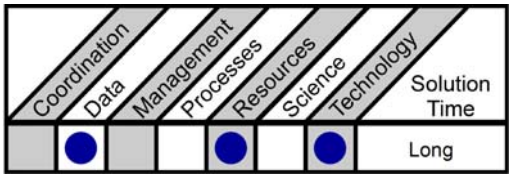
Users need a mechanism to allow feedback to product developers for future product improvement efforts. This mechanism would allow developers to understand how users are attempting to use their products and how their products are currently performing. Feedback would allow developers to be more responsive to the needs of the community. An accessible means of providing feedback would encourage the community to provide this vital information to developers, resulting in essential product improvements.

5.3 Consistent dissemination of timely products and services to model users is needed.



Many users are particularly pleased with ROMAN—most users state that ROMAN is an excellent source of data. Other systems that also received high marks were FX-NET and FireFamily Plus.

5.4 More products need to be available in low bandwidth formats for users using telephones and/or PDAs to receive the data.



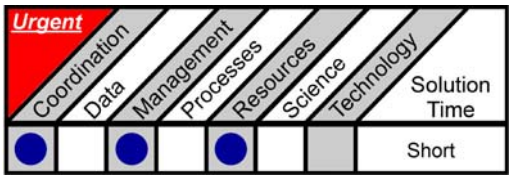
As described in Section 4.1.d, many users have limited access to fire weather products, especially when dealing with active wildland fires. Products intended to inform users of near-term threats or changing conditions need to be available to a wide variety of low-bandwidth users. Greater use of text information and PDA-viewable formats would vastly improve operational weather support to these sectors within the wildland fire community.

5.5 Wildland fire weather users and providers require robust, real-time access to weather data, to include increased continuity of operations planning.

Wildland fire weather users make time-critical decisions based upon the latest wildland fire weather products and services. Their ability to make accurate, time-critical decisions is affected by the timeliness and availability of these products and services. Given the relentless cycle of wildland fires in recent years, it has become increasingly crucial that wildland fire weather data always be available,

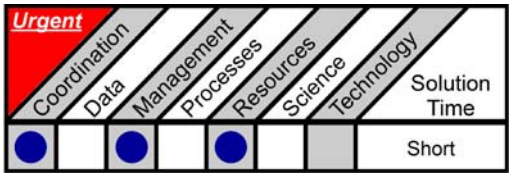
with robust backups tested and in place, to ensure that users have the information they need to increase their ability to protect lives and property threatened by wildland fires.

5.5.a Wildland fire weather users require a robust continuity of operations plan for the Geostationary Operational Environmental Satellite (GOES) Data Collection System (DCS), which serves as an integral mechanism for this flow of data.



GOES DCS is a major node of observational data. However, because it is not currently classified as an important operational system within NOAA's National Environmental Satellite, Data, and Information Service (NESDIS), it does not have a robust backup. The observational data provided by GOES DCS provide critical support to the wildland fire community. Therefore, a robust backup capability is essential.

5.5.b Wildland fire weather users require a robust continuity of operations plan for the Automated Sorting, Conversion, and Distribution System (ASCADS), which serves as a crucial node for weather data flow.



ASCADS is a potential single point of failure for vital fire weather observational data. A robust backup capability is needed to ensure fire weather users have uninterrupted data for their operational use.

Functional Area 6
Education, Training, Outreach, Partnering, and Collaboration

The scope of this functional includes education, training, outreach, partnering, and collaboration activities that support sound land management decisions during wildfire, prescribed fires, and WFU fires. Of particular interest are (1) existing types of wildland fire education, training, outreach, partnering, and collaboration, (2) gaps in these activities with respect to meeting user needs, and (3) how the wildland fire weather community can better educate and reach out to wildland fire professionals, as well as to the public and others who use wildland fire information.

The following topics are within the scope of this functional area:

- Current education, training, outreach, partnering and collaboration processes, including their intended audiences and purposes, in use at fire weather users' organizations
- Who in a fire weather user's organization uses and conducts education, training, outreach, partnering and collaboration; why and how they employ these activities and the topics covered in them to support wildland fire objectives
- Examples of collaborative and partnering activities in education, training, and outreach
- How research products/results are transitioned into operational education, training, and outreach programs
- Opportunities where increased education, training, outreach, partnering, or collaboration can improve products and services delivered to the professional wildland fire community or to their "service customers" (state and local officials, those at immediate risk from wildland fire danger/incidents, the general public, etc.)

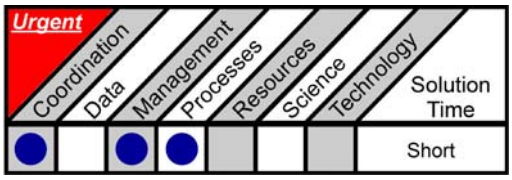
The two major needs identified by the JAG for this functional area address training for the wildland fire community. The first, which deals with the *content* of training processes and programs, is spelled out through its three subneeds: a review of existing training to ensure fire weather personnel are trained in their core proficiencies (6.1.a), validation of training programs against requirements and improvements to them based on best practices (6.1.b), and development of a comprehensive certification program for fire weather training (6.1.c). The second major need (6.2) relates to improving and expanding the methods for *delivering* training.

6.1 Fire weather personnel need to be properly trained, training programs need to be improved and validated, and eventually, a comprehensive training and certification program should be implemented.

Training, education, and information needs across the wildland fire weather community vary widely. The difficulty experienced by some users in locating training, products, or information is a particular challenge. The wildland fire weather community at large needs to know where and how to access fire

weather information. Ideally, access to this information should be consolidated through an Internet interface, and the number of Internet sites consolidating this information should be limited. Both common and unique training and informational requirements must be identified and met. In addition, training in product use must accompany current products and the implementation of any new products.

6.1.a A review of training processes and programs for quality, availability, consistency, currency, and standards across the fire weather community is needed.

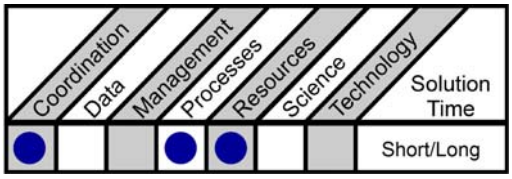


Training is a consistent requirement for success, and training requirements are ever-changing with new processes and technologies. An assessment of the quality of formal training should include factors such as the qualification of training instructors, the validation of training requirements, and the currency of the training materials being used.

- An assessment of training on the use of fire weather products and information should be evaluated for ease of availability, currency, and simplicity with regard to users' needs.
- User feedback from both formal training and training on the use of products and information should be incorporated into training revisions and improvements.

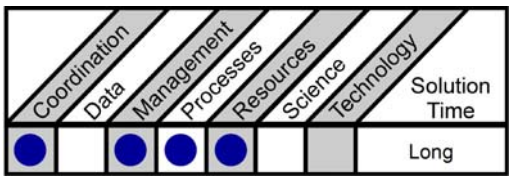
Training processes and programs should include their own periodic validation reviews to ensure the curricula are current and in concert with training requirements. In addition, training processes should be reviewed for management emphasis, education and outreach, and awareness of decisionmakers.

6.1.b Training programs need to be validated against requirements and improved via use of best practices.



Formal training programs and training on the use of products and information should be routinely validated against established training requirements for both users and providers. A cross-feed communication mechanism may provide a means of sharing and leveraging best practices.

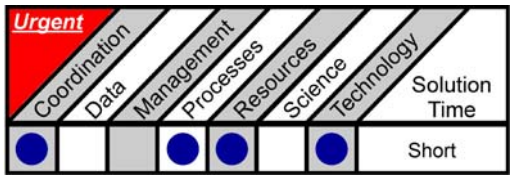
6.1.c A comprehensive training and certification program needs to be developed, ensuring the fire weather competency of all fire weather personnel supporting wildland fire activities.



Fire weather providers and users require different levels of training in their core fire weather proficiencies. These core proficiencies need to be identified (or developed if none exist) and documented as core training requirements. These requirements should then serve as the basis for training.

Training courses, instructor certification, course material validation, and the common and unique training requirements that drive curriculum development should be centrally managed and coordinated.

6.2 Training agencies need to make better use of a full range of training delivery methods, with a particular focus on distance-learning needs.



Challenges to effective partnering and collaboration are evident. As new Internet based training methodologies continue to evolve and improve, collaborative and partnering initiatives across the community should also evolve and improve and become more targeted and frequent. Partnering and collaborative processes can improve significantly with improvements in formal collaboration using the latest Internet technologies that reach across all levels of the fire weather community. Initiatives are needed to foster the standardization of the wide variety of data, formats, and systems being used.

Funding for training travel and staffing shortages in the work center are persistent challenges noted by the community. As new Internet-based and other state-of-the-art training methodologies continue to evolve and improve, existing training processes should be routinely reviewed and new methods implemented to minimize the need for costly travel and time resources and to make training as widely accessible as possible.

Functional Area 7
User Response, Decision Support, and Resulting User Impacts

The downstream consequences to users of fire/atmosphere prediction-related products and services determine their utility and merit. These consequences include how users respond to the products, how well the products support decisionmaking and operations in the user community, and other impacts on users. This functional area focuses on short-, medium-, and long-term decisions and the timeliness, understandability, accuracy, and spatial coverage of the forecast products. The following topics fall within the scope of this functional area:

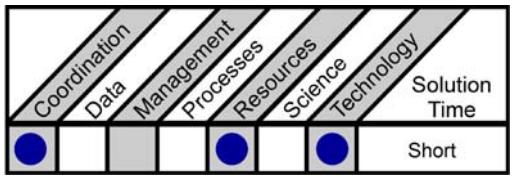
- Current decision environments used in the wildland fire community
- Current forecast products and services designed to inform these decisions
- The timeliness, spatial and temporal dimensions, and accuracy needs of management decision environments for the wildland fire community
- The social, political, environmental, and fiscal impact of management decisions and the associated importance of timely, accurate fire weather forecast products
- Existing and potential capabilities in the Federal sector
- Potential partnerships
- Potential new products to meet identified gaps
- Obsolete products that should be removed from operations

The JAG analysis for this area documents and recommends requirements and capability needs (knowledge gaps) for the wildland fire/atmospheric interface in the following topical areas:

1. Fire weather forecasts
2. Real-time fire planning, mitigation, and suppression
3. Fire danger and behavior
4. Air quality and smoke behavior
5. Climate variability implications for fire severity

The analysis defined general research knowledge gaps, identified areas of likely research partnerships, and addressed general guidance on the time and resources that will be needed to fill these gaps. Three major needs were identified for this functional area: better coordination between users and those who develop and deliver fire weather products and services, a repository of decision-support tools that includes feedback from and expert help to the users, and a specific need for better decision-support tools in the area of smoke management.

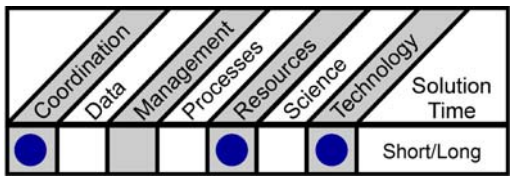
7.1 There is a need for better coordination between the development, delivery, and user communities in the development of products and services.



Better coordination among these communities would provide mechanisms for improvements to: user feedback for model evaluation, developer's understanding of user needs, consistent and standardized documentation and training for models and databases. The communities identified include the National Weather Service, Area Coordination Centers, Federal agencies, fire customers, and local media. A tool repository that provided a consistent mechanism of access, documentation, delivery, training, feedback, and expert help is definitely needed.

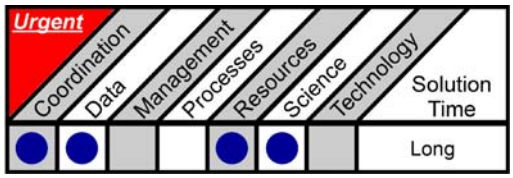
The fire community requires end-to-end decision support, that is, meteorological forecasts combined with fire behavior, fuel moisture, smoke production/transport/chemical evolution, fire danger, and/or ecological/forest growth models. As a first step, focused technology transfer could link existing model components for immediate benefit. The key is linking the necessary components (overcoming format and ownership issues) toward bringing together weather forecast fields (such as wind speed and direction) with other components (such as fire behavior modules) to produce the critical pieces of decision information identified in this survey (i.e. fire rate of spread). As a second step and intermediate term solution existing technology available in research could be transferred to operations. One context that might speed this process is the Developmental Testbed Center (DTC), a distributed facility providing support to the numerical weather prediction community test model developments that address operational needs and accelerate their adoption in the operational modeling community. Now that the Weather and Research Forecasting Model (WRF) has been adopted at NCEP as the North American Mesoscale (NAM) model, the DTC can be used to test and accelerate into operations not just changes to the weather model core but coupled modeling components such as fire behavior and smoke transport. A third step is to recognize and address long-term research problems such as improving numerical weather prediction to the accuracy needed.

7.2 A repository of decision-support tools is needed that provides a consistent mechanism of access, documentation, delivery, training, feedback, and expert help.



The community is fortunate to have many decision-support tools currently available. However, due to their growing number, the community is unaware of many of these tools. Furthermore, information on how tools can and should be used isn't as complete as it should be. A common repository for this information would improve community awareness of these tools and make them more accessible.

7.3 Users need more smoke management decision-support tools.



A significant number of responders said current weather support did not support smoke management decisions, either because they are required or preferred to receive their smoke management weather input from other sources – outside NWS (state, U.S. Forest Service Geographic Area Coordinating Centers). Additionally, smoke forecast tools were among the least available and/or accurate, according to respondents.

Example responses about how current weather forecasts support smoke management were: "need improvement," supports smoke management "very little," "info is very general," and "accuracy falls short of desires."

There were many references made to BlueSkyRains (www.blueskyrains.org) as quality input to Pacific Northwest smoke management.

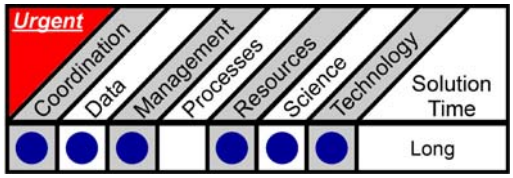
Functional Area 8
Funding and Human Resources (Crosscutting)

This crosscutting area documents and recommends funding and human resource requirements and needs to support all the other functional areas covered in the assessment. For purposes of this needs assessment, the funding and human resource needs considered are only those related to meeting the needs of information providers and users for weather and climate information products and services in wildland fire, air quality, and fuels management activities. The following topics are covered in this functional area:

- Staffing needs, including numbers of employees, job series, skills, etc.
- Equipment needs
- Funding requirements
- Additional capabilities or enhancements for wildland fire operations and readiness
- Opportunities to improve funding and human resources

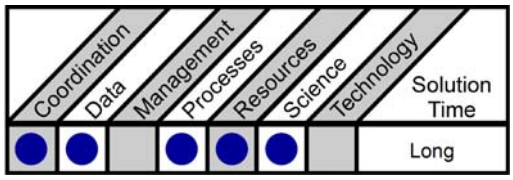
One of the two major needs identified in this functional area is for funding to implement the characterization of the current atmosphere described under need 1.1.a. The second addresses the specific problem of improving traditional approaches to fire weather to deal effectively with smoke management in the context of new air quality requirements.

8.1 Program resources are needed to meet the fire community's need for a real-time 4D characterization of the atmosphere and Earth's surface (see Functional Area 1).



Overwhelmingly, the single most acutely recognized funding shortfall was for more and better fire weather observations. This was most often directed by the fire community toward the acquisition, operation, and maintenance of RAWS stations. A strong opinion was conveyed that more remote stations are needed, and that RAWS maintenance must be improved. Better use of the observational data was also highlighted on a number of responses: storage and accessibility of fire weather observations was thought to be an insufficiently funded imperative. However, despite the widespread support for RAWS specifically, the community at large is really seeking better observational information. RAWS is most frequently mentioned because it is the system in which the community is most familiar. The significant issue here is the need for better resources to develop and implement an integrated observing strategy, as called for in need 1.1.a.

8.2 Program resources are needed for improved smoke forecasts (more training, better models, and improved smoke product dissemination) to link traditional fire weather disciplines with newly emergent air quality requirements.

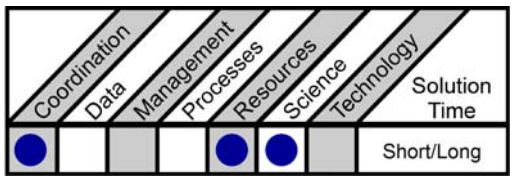


The sentiment expressed by users who commented on this problem is that more resources are needed to bridge the gap between the traditional fire weather community and the air quality monitoring community. This need for funding is closely related to need 2.1.b in fire weather R&D, need 3.2 in forecast products and services, need 4.1.a in modeling and prediction, and need 7.3 for decision-support tools.

Functional Area 9
Socioeconomic Factors

This functional area documents socioeconomic factors in community response to wildland fire hazards and incidents. The socioeconomic factors covered in the user inputs and the JAG analysis includes public awareness of wildland fire dangers, mechanisms to improve public awareness, and considerations of methods to increase appropriate public response to wildland fire dangers. The major need in this area, as defined by the JAG from its analysis of user input, is for improving the wildland fire community's access to and use of the best available tools for public outreach and education.

9.1 The fire community needs to tap into state-of-the-art socioeconomic tools to reach out to the public to better inform and educate them on the importance of understanding, mitigating, and preparing for wildland fire.



The science of fire weather has far outstripped the ability of the current fire community to effectively communicate fire risk and fire protection to the public, and many available communication resources are being underutilized in this cause.

- The public needs more information on how weather impacts wildland fire.
- The public needs more information on how weather affects smoke and what how the two relate to public health.
- The public needs a greater understanding of the relationship between climate change and wildland fire.
- The public needs relevant information regarding what they can and should do in order to reduce their risks associated with wildland fire.

Framing Concepts for an Implementation Plan to Meet Wildland Fire Weather Needs

The needs statements in this report synthesize and summarize the input received from a broad cross-section of users and providers throughout the wildland fire community. This report thus effectively answers the first part of the request from the WGA as stated in its Policy Resolution 05-04: National Wildland Fire Weather Program. The second part of the WGA request was for a framework through which the NOAA/NWS and the USDA's Forest Service Predictive Services, as well as other partners in providing fire weather information, can meet these needs. The JAG/NWFWNA foresees providing the requested framework through an Interagency Implementation Plan to Meet National Wildland Fire Weather Needs. Development of this implementation plan will include the following steps:

- Assess the capabilities of the provider and research agencies with respect to the needs stated in this report. Where needs are not being met (where capability gaps exist), determine whether:
  - Current programs can meet the need, and if so, the current time line by which the capability gap can be closed, or
  - New efforts/programs/resources are needed to close a capability gap that current programs do not address as currently planned.
- Coordinate with the cognizant Agency managers, technical leads, etc., on effective implementation approaches for closing capability gaps where new programs/projects/ resources are needed.
- Develop an interagency coordinated implementation plan that integrates current programs and plans with suggested new activities and that provides a time-lined and resource-based framework for meeting national wildland fire weather needs. Use the needs stated in this report as a basis for national wildland fire weather needs, to be updated and validated through ongoing interactions with the user and provider community.
  - Define both near- and intermediate-term priorities.
  - Recommend new initiatives and improvements in existing services, to be considered in Federal agencies' ongoing program review and reevaluation of products and services.
  - Identify partnering opportunities, both horizontal (e.g., across Federal agencies or across multiple State entities) and vertical (e.g., Federal-State partnering, commercial-State).

As the JAG performs these next steps in creating an implementation plan, it will be extremely important to leverage existing programs and initiatives of the responsible Federal agencies, as well as existing and forthcoming technologies, to ensure that the resulting plan is cost-effective and feasible.

Leverage existing programs and initiatives of the responsible Federal agencies

Existing programs and initiatives, as well as proposed program activities, can be effectively leveraged because wildland fire weather needs are generally consistent with the high-level goals and initiatives of NOAA and the Department of Commerce. For example, need 1.1.a for a real-time, observationally based, gridded characterization of the current atmosphere is consistent with NOAA strategic goals for the Integrated Earth Observation System (IEOS) and the international commitment to the Global Earth Observing System of Systems (GEOSS). Both the needs identification/validation part of the NWFWNA and the steps to develop an implementation plan are consistent with the ongoing NWS initiative for comprehensive and analytical reviews to determine emerging new or revised requirements for products and services. In this context, the origination and validation of wildland fire weather needs with the external user community (wildland fire weather community) is in step with NOAA policy.

Improvements in land-based Doppler weather radar capabilities, such as multifunction phase array radar (MPAR), that are needed to improve forecasts for hurricanes after landfall will also contribute to improved fire weather observations and forecasts of winds, precipitation, and aerosol (smoke) plume transport. The NOAA goal for improved climate forecasting is consistent with the climate-related aspects of fire weather needs 2.1.c and 4.1.c. The 2004 OFCM report, *Federal Research and Development Needs and Priorities for Atmospheric Transport and Diffusion Modeling*, includes R&D recommendations for high-resolution plume tracking and modeling, and for air quality/constituents modeling, that are relevant to wildland fire weather needs 2.1.b, 3.3.d, and 8.2.

The types of social science research and assessment tools required to address wildland fire weather need 9.1 are similar to those recently defined as research needs in the social sciences to improve the hurricane forecast and warning system.[1] Improving preparedness and response to warnings, civic and personal decisionmaking, understanding how communities and individuals respond to evacuation orders, and the valuation of social and economic impacts are topics relevant to wildland fire threats as well as to landfalling hurricanes. In the area of information dissemination about severe events, information technology and social science to improve warning systems (who gets the warning, and what information do they get) are crosscutting needs for hurricane warnings, severe weather events (tornadoes, flash flooding, river flooding), surface transportation weather, and urban meteorology, as well as for wildland fire weather.

The need to transition research results more rapidly and efficiently into operations has been a common theme in OFCM reports on tropical cyclone R&D, surface transportation weather, urban meteorology, aviation weather, and wildland fire weather. While differences will arise for specific application areas, best practices for transitioning research can be collected and shared to overcome the difficulties in putting research results and new tools into operational products and services.

Leverage existing and forthcoming technologies

In the near term, wildland fire weather needs for improved observations—necessary both for reporting on current conditions and to improve forecast products—can leverage the existing generation of remote-sensing technologies, including airborne and satellite-based observing systems

[1] Joint Action Group for Tropical Cyclone Research. *Interagency Strategic Research Plan for Tropical Cyclones: The Way Ahead.* OFCM, 2007. Pp. 5-10 to 5-12.

and land-based weather radar. As new satellite-based sensors and systems become available to meet broader IEOS and GEOSS objectives, their applicability to wildland fire weather needs will need to be assessed and exploited as appropriate. As noted above, MPAR is another emerging technology that will help improve the quality and quantity of observations relevant to fire weather conditions and forecasting. Targeted observing strategies using unmanned air systems will, in time, provide high-value observations on current fire conditions and the input needed to improve the accuracy of high-resolution models.

A nationwide system of collecting mesonet data and making it readily available is an important objective for surface transportation weather, atmospheric transport and diffusion modeling, and wildland fire weather (see needs 1.1.b, 1.1.c, 5.1, and 8.1). Fire weather observational needs should be included in the planning for a nationwide system of multifunctional mesoscale observing networks.

Initiatives to advance NOAA/NCEP modeling capabilities and the interface between NCEP model output and specialized applications serving specific user communities are underway or planned: These activities, which can support wildland fire needs 3.1.b, 3.1.c, and 4.1 and its subneeds, are also needed to support applications in urban meteorology, surface transportation weather, and aviation weather.

Appendix A

Western Governors' Association
Policy Resolution 05-04

Western Governors' Association
Policy Resolution 05-04

June 14, 2005
Breckenridge, Colorado

National Wildland Fire Weather Program

A. BACKGROUND

1. As a consequence of decades of fuel accumulation in our nation's forests and rangelands coupled with persistent drought, state and federal fire managers are faced with larger, more explosive, and more costly wildfires than in any period in history.

2. Catastrophic wildfire is a growing national issue, demonstrated by the Florida wildfires in 1998 and 1999 and wildfires in Western states over the past five years. Between 2000 and 2004, Western states experienced severe fire seasons that set new benchmarks in terms of damages, losses, and cost.

3. Large, damaging wildfires are costly to suppress, and they can also cause severe economic impacts to communities and state economies. Based on the experience over the last decade, 98% of wildfires are successfully extinguished during initial attack, however, 80% of wildfire costs are incurred when managing the 2% of wildfires which grow into large fires. Over the 5-year period from 2000-2004, federal wildfire suppression costs averaged $1.16 billion per year and are rising. With the addition of state and local fire suppression efforts, these costs likely approach $2 billion in severe years. Public health impacts are also increasing as the population increases in the wildland urban interface areas and smoke dispersion from wildfires and prescribed fires impact vulnerable citizens with respiratory ailments.

4. In order to reduce the risk of loss, the fire management agencies in the United States have begun moving aggressively to deal with the tremendous accumulation of biomass which contributes to unwanted wildfire behavior. Much of this work is accomplished through prescribed fire projects and increasingly the management of natural ignitions.

5. In order to effectively and cost-efficiently manage and suppress wildfires, including through the use of prescribed fire, it is critical that fire managers have timely, accurate and detailed information regarding current and predicted fire weather and associated climate services. The National Oceanic and Atmospheric Administration's (NOAA's) National Weather Service (NWS), through its fire weather program, is the national agency in the Department of Commerce (DOC) which provides this critical information. The federal wildland fire agencies' Predictive Services integrate weather, climate and fuels information into fire environment products for the allocation and prioritization of fire management resources. The fire environment refers to those elements comprising fire meteorology, fire climatology, fire danger, fire behavior and fuel conditions as derived from weather and climate.

6. NOAA's NWS does not have a clear, legislative mandate or identified funding line items to operate its fire weather program. As a consequence, their capability to support sound fire management decisions may not be able to keep pace with the increasing demands.

7. The current NWS policy on issuing site-specific spot forecasts is to only issue spot forecasts for prescribed burns for federal lands and federal assets, and for requests from public safety officials. Unless a state or local government can represent that there is a public safety concern or that federal assets are at risk, state and local governments must pay the private sector for spot forecasts.

8. Coordination currently exists on the operational side of wildland fire programs, including:

   - *The Wildland Fire Leadership Council (WFLC)* was established in April 2002 by a Memorandum of Understanding between the Secretaries of Agriculture and the Interior. The purpose of the council is to support the implementation and coordination of the National Fire Plan and the Federal Wildland Fire Management Policy.
   - *The National Wildfire Coordinating Group (NWCG)* – the purpose of NWCG is to coordinate programs of the participating wildfire management agencies so as to avoid wasteful duplication and to provide a means of constructively working together. The NWCG's Fire Environment Working Team (FENWT) was recently created to provide strategic guidance to Fire Danger, Fire Weather, and Fire Behavior issues and includes NOAA's NWS.
   - *The National Interagency Fire Center (NIFC)* in Boise, Idaho is the nation's support center for wildland fire management. Seven federal and state agencies work together at NIFC to coordinate and support wildland fire and disaster operations.

9. To increase the fire community's ability to plan and mitigate our Nation's fire and fuel problem, federal research entities were established to study fire and its effects. These research stations operate mainly within the USFS and have broad missions and goals. Valuable research is also being done at Universities, the University Corporation for Atmospheric Research (UCAR), NOAA, NASA, United States Geological Survey (USGS), the Environmental Protection Agency (EPA) and the private sector.

10. Despite current research programs on fire weather and fire environment, additional research and better coordination of existing research is needed to improve decision support for decision-makers charged with protecting the public and our natural resources. At the present, there is inefficient communication and collaboration on problem-solving between science and fire weather operations.

11. The fire weather observation network, called Remote Automated Weather System (RAWS), is not integrated into a comprehensive observing strategy, for example as part of the Integrated Surface Observing System (ISOS) and Global Earth Observing System of Systems (GEOSS).

12. Fire Weather information is critical for effective wildland fire managers and for the safety of firefighters. However, methods for using fire weather information are subjective and have changed little in decades. The advent of *digital weather databases, fire potential forecasts,* and the improvements of *high resolution multidisciplinary computer models* puts this nation on the cusp of a quantum leap in decision-making tools to support fire operations.

13. The Western Governors' Association (WGA) has related programs and resolutions that complement a fire weather program. Goal One of the 10-Year Comprehensive Strategy (*A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment*) calls for improved prevention and suppression strategies, and Goal Two speaks to reducing fuels in the wildland urban interface. The WGA resolution regarding drought (02-02) recognizes the relationship between drought and wildfire, stating that "extremely dry conditions have led to numerous forest and rangeland fires, burning tens of thousands of acres of land, destroying homes and communities, and eliminating critical habitats for wildlife and grazing lands for livestock." Finally, the Governors created the Western Regional Air Partnership (WRAP) for the purpose of developing data, tools, and policies needed by states and tribes to improve visibility in parks and wilderness areas across the West.

B. GOVERNORS' POLICY STATEMENT

1. Operational fire managers need improved products and services from NOAA's National Weather Service (NWS) which can be seamlessly infused into fire operations decision-making. To ensure the program has proper attention and funding, the Governors urge Congress to legislatively add fire weather including support for wildfire and prescribed fire management to federal, state, and local government agencies as a core mission of NWS and carry it as a funded line item in their appropriations.

2. The Western Governors urge NOAA to:
   - Incorporate a robust national wildfire and prescribed fire weather program into its strategic plan, and its 5 and 20 year research plans, and funding requests.
   - Complete a National Needs Assessment Report, by NOAA's Office of the Federal Coordinator for Meteorology, of federal, state and local fire managers needs for weather information in their wildfire and prescribed fire decision making processes and a framework to meet those needs by the NWS and Predictive Services.
   - Enhance and incorporate the fire weather observational network (RAWS) through agreements with the land management agencies into an integrated surface observing strategy, for example through ISOS and GEOSS.

3. The Western Governors believe an integrated fire weather and fire environment research program is critical for the effective management and health of U.S. forests and rangelands. To ensure the program has proper attention and funding, the Governors urge Congress to legislatively direct the National Academy of Sciences to conduct a review of

the research programs related to fire weather and fire environment (including Department of Agriculture, Department of the Interior, EPA, NOAA, NASA, and academia). This review should focus primarily on the coordination process between research programs and on processes to transfer research results into fire operations.

4. The Western Governors believe the nation would reap significant economic benefits by a new joint interagency effort to transfer new digital weather information and technology into operational fire management decision-making and planning. This new effort would have a high economic return on investment and significant public health benefits from improved smoke dispersion forecasts. The Governors urge Congress to legislatively identify and fund NOAA to organize a new joint interagency effort for improved fire weather, fire environment and smoke dispersion information with NOAA, USFS, DOI, EPA, NASA, states, and other federal and non-federal stakeholders to:

    a. Facilitate, integrate and transfer new science and technology into wildfire and prescribed fire operations

    b. Perform verification, validation, evaluation and assessment of operational fire weather data, products and applications.

    c. Provide science and technology training for forecasters and fire management decision-makers, technical support for new decision-support tools, and grant support for joint collaborative applied fire weather and fire environment science research.

5. The Western Governors believe the new robust applied fire weather, fire environment and smoke dispersion program needs to be effectively leveraged, integrated and coordinated with the 10-Year Comprehensive Strategy, the WGA drought program, and WRAP.

6. The Western Governors believe that weather, climate and hydrology data generated by the federal government should be available to all levels of government in an open and unrestricted manner. The Governors oppose making such data available only to the private sector for purposes of resale to states and local governments.

C. GOVERNORS' MANAGEMENT DIRECTIVE

1. The Western Governors' Association (WGA) shall post this resolution to its Web site to be referred to and transmitted as necessary.

2. WGA staff shall work with the states, the appropriate federal agencies, and Congress to implement this resolution.

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