

**NOAA Response to**

***Fire Weather Research:***

***A Burning Agenda for NOAA***

**A Report from the NOAA Science Advisory Board**

**Final Report, November 4, 2009**

## **Executive Summary**

In December of 2006, the National Oceanic and Atmospheric Administration's (NOAA) Science Advisory Board (SAB) established a Fire Weather Research Working Group (FWRWG), which issued its final report, and associated findings and recommendations, to the SAB in October 2008. These findings and recommendations were intended to assist NOAA senior management in priority setting with regard to the creation of fire weather research and development plans, as well as to improve operational, fire weather-related products and services offered by NOAA. Of the 46 recommendations, the SAB identified 11 as most critical. As NOAA continues to develop its fire weather program and strategy, the 11 critical recommendations will be considered as highest priority.

Per the SAB report, the key areas where NOAA should focus attention include the following (as condensed from the 11 priority recommendations). The specific SAB priority recommendations are listed by number after each item:

- Support research to develop a fire scale weather model that can be coupled to the relevant physics of fire spread models. Success requires close collaboration with fire behavior modelers at the National Institute for Standards and Technology (NIST), the National Center for Atmospheric Research (NCAR), the United States Forest Service (USFS), the U.S. Department of Interior (DOI), and university and private partners. (3.1)
- Support research and operational evaluation of a spectrum of available models for improved smoke and fire management decisions. NOAA research will collaborate with partners to provide leadership in technology transfer and act, along with our partners, as a central focal point for operational product deployment. (18.2 and 18.3)
- Develop, maintain and provide easy access to a standardized set of observed data from all available sources to support weather forecasters, model assimilation, and model validation. This includes maintaining provision of NOAA quality data to NOAA's Incident Meteorologists (IMETs) via a Thin Client. (2.1, 2.2, 14.1)
- Research means to creatively utilize NOAA's evolving fire weather forecast data sets to improve fire danger maps, since weather is such a critical component of fire danger. (5.1)
- Take steps to develop automated "intelligent assistant" software which incorporates very fine scale NOAA data sets into decision support tools for IMETs and Incident Commanders. This software will be used as a core nowcast and spot forecasting aid. (8.1)
- Ensure availability of NOAA's observational and forecast information via low-bandwidth technologies to ensure availability of the latest data in remote locations. (12.1)
- Continue support of joint projects with the U.S. Geological Survey (USGS) to develop rainfall rate thresholds in support of debris flow prediction in burn scarred areas. (15.1)
- Increase focus on fire weather in NOAA and National Weather Service (NWS) Strategic Plans, and establish a clear fire weather research focus and a fire weather test bed within NOAA. (18.1)

With a recent history of fire seasons becoming longer and more severe, attention to these critical items will serve the American public by fostering forecast enhancements, more timely and accurate data collection, and an increased focus to ensure rapid transition of new research into operations.

## **1. Introduction**

In December of 2006, the National Oceanic and Atmospheric Administration (NOAA) Science Advisory Board (SAB) agreed to establish a Fire Weather Research Working Group (FWRWG). The SAB chartered the Working Group to (1) ensure NOAA's fire weather research priorities meet the needs of the federal wildland management agencies, and (2) explore opportunities to leverage current NOAA internal and external collaborative fire weather research efforts to ensure improvements to NOAA's fire weather products and services. The FWRWG's findings and recommendations, as cited in its October 2008 final report entitled "Fire Weather Research – A Burning Agenda for NOAA", were intended to assist NOAA senior management in priority setting and in the creation of fire weather research and development plans, as well as to improve operational, fire weather-related products and services offered by NOAA.

The SAB report states that catastrophic wildfire is a growing national issue threatening life, property, infrastructure and local economies. This issue, coupled with increased recognition of the importance of weather and climate data to fire management, has led to calls from federal, state and local governments to improve fire weather services. For example, the 2001 Federal Wildland Fire Management Policy called for the development of a national plan for weather services to support state and local fire management agencies. More recently, state governments and associations have called for improvements in weather and climate information to support wildland management agencies and fire fighting communities. Specifically, in June 2005, the Western Governors' Association (WGA) approved a policy resolution calling for "applied research and technology development efforts to effect products and services that can be quickly and effectively transitioned into NOAA operations."

In 2007, NOAA's Office of the Federal Coordinator for Meteorology and Supporting Research (OFCM) released a "Fire Weather Needs Assessment" report in response to one of the recommendations from the WGA policy resolution. This report, created by an interagency Joint Action Group under the auspices of OFCM, identified the most pressing user needs related to fire weather among the user community. In particular, the report identified many needed improvements to NOAA's products and services, and uncovered a number of research and technology needs which require NOAA's action or involvement to enhance and extend its fire weather support.

As of the date of this report, OFCM is incorporating these needs into a final document which will contain recommended strategies for meeting the identified needs. OFCM has already advised that these strategies will closely match those cited in this report; namely, to focus on leveraging and strengthening existing partnerships to make progress with respect to the most challenging needs. In any event, this report complements the 2007 OFCM needs assessment report, and NOAA staff is now participating in a leveraged effort with OFCM to ensure both the OFCM needs and the SAB report recommendations are appropriately adjudicated.

## **2. Overview of Findings and Recommendations**

The SAB report strongly supports existing fire weather research and operational efforts and encourages NOAA to take a co-leadership role in addressing the scientific and technological gaps identified. The purpose of this document is to provide a formal NOAA response to the SAB on the recommendations made by the FWRWG in their 2008 report.

The SAB report identified 19 findings and 46 corresponding recommendations across a broad spectrum of need. As a consequence, the challenge for NOAA is to prioritize where to best utilize and leverage existing resources and focus resource requests on specific operational and modeling improvements. These recommendations are related to needed advancement in applied research and technology, and to organizational and strategic enhancements as related to fire weather needs.

NOAA accepts all of the SAB recommendations and has already made progress on some of them. Implementation of the recommendations can be grouped into three categories. These categories were created for the oral briefing to the NOAA SAB to highlight associated time lines and resource requirements:

- Those which can be completed in the near term (by 2012) utilizing current collaborations and resources, and presuming continuation of current collaborative commitments and resources.
- Those where progress can be made (through 2012), either by utilizing current NOAA resources or based on the expectation of partner support.
- Those areas where NOAA must expand partner collaborations and support (long term research), or secure additional resources, to progress to a point where new applications can be considered as ready for transition to NOAA operations.

Essential to making progress on the SAB recommendations is the collaboration process between NOAA and its land management partners, who share the national fire weather mitigation and suppression mission. Federal partners include (but are not limited to) the fire weather agencies within the U.S. Department of Agriculture and Department of Interior (including Predictive Services), the Environmental Protection Agency (EPA), the U.S. Geological Survey (USGS) and the National Aeronautical and Space Administration (NASA). Other key collaborators will include university research communities and private sector fire researchers, as well as those who use NOAA's products and services, including emergency managers and incident commanders. The collaboration process includes national and international Memorandums of Agreement (MOAs) between agencies, joint projects funded by the Joint Fire Sciences Program (JSFP), and information sharing through conferences and technical interchange meetings.

Section 3 below provides a summary of NOAA's position, status and plans with respect to the findings and recommendations. Of the 46 recommendations, the SAB identified 11 as most critical. NOAA will consider these as high priority needs of the fire weather community. These most critical SAB recommendations are identified in blue text within the Section 3 table. Some recommendations and responses are necessarily paraphrased for brevity within the table.

### 3. NOAA’s Position, Progress and Plans on SAB Findings and Recommendations

The following is a detailed response to each of the SAB Findings and Recommendations. The response to the recommendations is organized by the 19 Findings, and includes a summary of “Position and Progress” and “Plans and Partners”, for each Finding. Some of the Findings are similar in nature, as a result, the position and planning sections for them may also be very similar.

Finding	Position and Progress	Plans and Partners
<p><b>Finding #1:</b> An understanding of how fires interact with the full 3-D atmosphere is fundamental to both subjective fire weather forecasting and the development of numerical forecast tools.</p>	<p><b>Recommendations accepted.</b> The need to couple fire weather and behavior predictive models, and to improve sensing in the fire environment, have been established as critical by the NWS’ Science and Technology Roadmap for Fire Weather. This need is also cited in documentation developed for budget alternatives submitted by NOAA’s Office of Oceanic and Atmospheric Research (OAR) and NOAA’s National Centers for Environmental Prediction/ Environmental Modeling Center (NCEP/EMC) for operational model delivery.</p>	<p><b>Partnerships include:</b> The National Institute for Standards and Technology (NIST), universities, State and National Park Service, The United States Forest Service (USFS), NOAA’s NWS and OAR, NASA, Southwest Research Institute (SwRI) international research and operations partners, and state and local emergency management groups. Through these partnerships, proposals have been or are being developed. These proposals have been submitted to the National Science Foundation (NSF), NOAA and to the Joint Fire Sciences Program (JSFP) for funding. Cooperation is also underway with USFS research as well.</p>
<p><b>Finding #1 Recommendations:</b> <b>1.1:</b> Conduct detailed case studies at wildland fires with the goal of understanding fire/atmosphere interaction and validating numerical models. <b>1.4:</b> With land management agencies, conduct large-scale, well-instrumented, controlled burns to examine 3-D atmospheric response to fires.</p>	<p>Lack of observations in and near the fire environment has been identified as a data gap in OFCM’s report: “National Wildland Fire Weather: Summary of User Needs and Issues”. It is also highlighted as a gap by research experts at several professional fire conferences.  Discussions with university partners, NIST, USFS, and land management partners have begun to uncover how these experiments would investigate optimal fire area sensors and their placement, and to verify fire scale data assimilation, predictive weather and fire behavior models.</p>	<p>NOAA/OAR’s Earth Systems Research Laboratory’s (ESRL) Global Services Division (GSD) and Physical Sciences Division (PSD) are coordinating with the NOAA and NASA Unmanned Aerial Systems (UAS) Program, the NOAA/NIST Fire lab, the University of Colorado (CU), (USFS) and private sector partners to identify potential, large-scale prescribed burn dates and locations.  Observation leveraging and direct coordination is also planned with USFS at upcoming fire management workshops (late 2009 into early 2010) to outline strategic plans for combining observation resources. The coordination will include discussion on prescribed fire collaboration.  NWS Incident Meteorologists (IMETs) would actively participate in field experiments to provide operational insight and partner dissemination.</p>

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<p><b>1.2:</b> With federal fire partners, and through JFSP and the National Science Foundation (NSF), explore establishment of a jointly-funded fire weather research program among federal agencies, universities and industry</p>	<p>NOAA participates in conferences and technical interchange meetings to define resources needed to progress on the biggest challenges, especially with respect to fire scale numerical models and fire environment observations.</p> <p>Consultation directly with JFSP has led to recent opportunities to request funding for fire weather research, through the JFSP proposal process.</p>	<p>In order to publicize JSFP and NSF proposals to all collaborators within the wildland fire community, NOAA needs to establish a formal, standing fire weather research body, led by OAR, to leverage efforts among all research entities. These proposals include private sector partners, NOAA Cooperative Institutes, NOAA NWS, NCEP, NIST and NCAR. Work is planned with JFSP to include OAR research plan into the strategic fire behavior research planning diagram.</p>
<p><b>1.3:</b> Use satellite-derived estimates of fire radiative energy to specify surface boundary conditions to characterize vertical atmospheric structure and transport over fires.</p>	<p>NWS produces operational smoke predictions, based on NOAA/OAR dispersion models linked to NCEP operational weather predictions. ESRL/GSD and OAR/Air Resources Laboratory (ARL) chemistry models are currently using satellite-derived fire data (the NOAA’s National Environmental Satellite, Data and Information Service’s (NESDIS) ABBA product) in plume rise calculations and smoke extent analysis.</p> <p>New GOES technology will become available within the next year, enabling finer scale assessment of radiant energy, at much higher temporal resolution (every five minutes).</p>	<p>ESRL/GSD, CU, NIST and the USFS research station in Salt Lake City, UT will partner on subsequent JSFP proposals to conduct field studies. These proposals are submitted on a yearly basis. Due to the need for additional computing needs for this research, out-year funding will be needed to conduct research in the area of utilizing fire radiative energy data in the atmospheric models, and to complete the field studies. New GOES imagery will become available to assess energy output of fires and associated vertical transport potential.</p>
<p><b>Finding #2:</b> All available data sources, including new sources of remotely sensed data, should be explored and utilized to improve initialization of NOAA’s numerical prediction models.</p>	<p><b><u>Recommendations accepted.</u></b> NOAA recognizes the need to improve NOAA’s operational NWP models and to develop a spectrum of high resolution models.</p>	<p>NOAA must leverage partnerships and funding opportunities to facilitate research activities designed to assimilate in-situ observations into landscape-scale weather forecast models. NCEP proposes to assimilate these data into the daily high resolution national model. These observations are also essential to the verification plan for weather and fire behavior forecasts. NOAA will continue to fund expansion of mobile electronic theodolites to sense the atmosphere at fire scenes.</p> <p>Resources will be needed to facilitate this fine scale assimilation research.</p>

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<p><b><u>Finding #2 Recommendations:</u></b>  <b>2.1:</b> Assimilate output from all available local observation sources, including those from ground-based radars, profilers, Unmanned Aerial Systems (UAS) and satellite sensors for fire weather forecasting and fire danger mapping.</p> <p><b>2.2:</b> Explore the use of remote sensing methods, including ground-based radar High-Altitude/Long Endurance UAS and satellite for sustained, continuous monitoring and forecasting of tropospheric microscale weather, surface conditions and fire growth during wildland fires.</p>	<p>ESRL/GSD and NIST are coordinating with the NOAA UAS Program, NASA, USFS and the CU UAS Program to identify sensors and flight path scenarios to test a small UAS platform over a prescribed burn. Several meetings and presentations on sensors by the UAS program, the Micro Dropsonde project and ESRL's mobile radar project have been conducted with the GSD and NIST modeling and planning team.</p> <p>Private sector partners have also been important partners during preliminary UAS atmospheric sensing test flights. Available resources should be leveraged.</p>	<p>Results from the integrated field studies as cited in Finding #1 (i.e., identification of the most useful combination of observing systems, forecasts and decision support tools) should be integrated in fire forecasting operations. Advanced data assimilation techniques will be evaluated during field studies to find the optimal use of in-situ and remotely sensed observations. Utilizing a proposed fire weather and fire behavior modeling test bed, ensemble modeling will be evaluated.</p> <p>Observation leveraging and direct coordination is also planned with USFS at upcoming fire management workshops (late 2009 into early 2010) to outline strategic plans for combining observation resources.</p> <p>Proposals to the NSF and JSFP will be submitted for FY10 &amp; FY11 funding. All named collaborators are involved in the proposal process.</p> <p>IMETs are equipped with electronic theodolite technology that needs to be engineered to allow the fire weather modeling system to utilize these important in-situ observations.</p>
<p><b><u>Finding #3:</u></b> New modeling systems that simulate weather and fire behavior in complex terrain are promising, but their performance has not been sufficiently validated due to limitations in experimental studies near wildland fires. This includes uncertainty in validation of initial and boundary conditions for these models.</p>	<p><b><u>Recommendations accepted.</u></b>  Limited resources have allowed only preliminary interaction with land management, NOAA, NIST and university partners to identify current efforts and begin to identify clearly defined research tracks.</p>	<p>To broaden this effort, NOAA NWS and OAR have submitted modeling research and validation proposals internally, to JFSP and to NSF.</p> <p>Proposals to the NSF and JSFP will be submitted for FY10 &amp; FY11 funding. All named collaborators are involved in the proposal process.</p>
<p><b><u>Finding #3 Recommendation:</u></b>  <b>3.1:</b> Increase research and development of integrated fire weather modeling systems across a range of conditions, and with a variety of federal, university and private sector partners. The long-range goal is more accurate simulation of fire behavior in complex terrain and at the Wildland-Urban Interface (WUI).</p>	<p>In FY08, an ESRL fire-scale modeling team investigated coupling a 500-meter fire scale model with a USFS fire behavior model (FARSITE). A report detailing the findings was submitted to the GSD Director and GSD fire weather project manager for review.</p> <p>FY09 funding provided resources to allow NOAA research to interact with</p>	<p>The development of fire scale, coupled weather and fire behavior models is a long-term, complex project. An experimental, 3 km rapid refresh model will be run by ESRL for evaluation and use by industry and researchers. Collaboration with NOAA/Air Resources Laboratory (ARL), NWS/NCEP, and IMETs will provide additional output evaluation and operational use feedback.</p>

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	<p>modeling partners and to run an experimental 3km rapid refresh model over the Western US during the fire season.</p> <p>NIST and NOAA/OAR have established an MOA to begin research on the algorithms needed to integrate these models. The NCAR WRF/Fire model is being evaluated as a framework for this research.</p> <p>It is also recognized that operational questions and needs must be met with a wide spectrum of fire weather and fire behavior models. These include simple fire spread models, as well as complex physics-based landscape models.</p>	<p>NIST, NCAR, the USFS and NOAA fire weather and fire behavior scientists are continuing to conduct technical interchange meetings. These discussions include the topic of fire scale observations for validation.</p> <p>NCEP and the NWS Fire Program have submitted mesoscale analysis and model validation topics for consideration by the JFSP. The JFSP will consider these ideas for potential partner funding.</p> <p>As operational models are proposed, NOAA will provide leadership in assessing operational model development, and its transition to operations. Additional funding will be needed.</p>
<p><b>Finding #4:</b> NWS currently provides relatively coarse resolution weather data to fire incidents. NOAA's IMETs currently have no tools for objectively downscaling weather information to a scale closer to that of the vegetation and topography. This mismatch of scale leads to large uncertainty in the weather input.</p>	<p><b>Recommendations accepted.</b></p> <p>The establishment of a central test bed with an associated archive capability is essential to research and validation efforts.</p>	<p>In the longer term, downscaling of model forecasts over complex terrain will provide wind and additional atmospheric elements important to forecasting the weather in the fire environment.</p> <p>This work should be a part of the larger fire-scale weather research effort.</p>
<p><b>Finding #4 Recommendations:</b></p> <p><b>4.1:</b> Partner with federal wildland management agencies to establish a central data repository (archive) with entries in standard format to facilitate post fire analysis and assist in verification and validation studies.</p> <p><b>4.2:</b> Explore and validate tools for generating, from coarser grids, detailed weather grids incorporating terrain.</p> <p><b>4.3:</b> Maintain gridded forecasts (and observed/ analyzed weather) in a database to assist future fire model development and testing.</p>	<p>NOAA OAR and NWS are collaborating on a 4-dimensional data repository (4D data cube via the NextGen program) that will be compatible with Geographic Information Systems (GIS), and will be web-accessible and available to research and operational partners.</p> <p>Current proprietary tools used to downscale wind forecasts are WindWizard and WindNinja. This is an acceptable short term solution.</p>	<p>NOAA must leverage funding opportunities to extend the test bed to provide data to a services delivery proving ground for public product development and decision support tools. Funding would facilitate OAR &amp; NWS collaboration on development of downscaled, terrain-following models and establish a 4-D data repository that is web addressable and GIS compatible.</p> <p>This process will inform operations to research requirements analysis and assist in validating research to operations transition. The validated decision support information will be aligned with Land Management agencies decision support tools, such as USFS' Wildland Fire Decision Support System (WFDSS).</p>

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		<p>Collaborations with the NWS, NCAR and the FAA on the 4-D Data Cube are supported via current and proposed funding (NextGen).</p> <p>One OAR position has been funded to begin downscaling weather models to a sub-1km domain in complex terrain.</p>
<p><b>Finding #5:</b> The observed fire danger map underutilizes NWS weather observations and analysis tools. A single data network is needed to facilitate integration of (and quality control on) the many disparate sources of observations relevant to fire weather and its modeling.</p>	<p><b>Recommendations accepted.</b> NOAA recognizes the wealth of observational datasets available to help answer fire management questions concerning fire danger.</p>	<p>NOAA has requested funding through the appropriate internal process, and must also leverage external funding opportunities to facilitate data assimilation research and evaluation, and to fund needed tool development activities.</p>
<p><b>Finding #5 Recommendations:</b></p> <p><b>5.1:</b> Use data assimilation systems described in Recommendation 2.1 to generate high resolution fire danger maps.</p> <p><b>5.2:</b> Use the existing National Fire Danger Rating System (NFDRS) processor at the Scripps Environmental Prediction Center or the Rocky Mountain Center to compute fire danger maps with sufficient frequency to depict diurnal variations that may affect fire potential.</p>	<p>The Meteorological Assimilation Data Ingest System (MADIS), which is a transition project led by NWS and OAR, will serve as an interface to State and Local land management observation data and will be utilized to generate fire danger maps.</p> <p>New generation data assimilation systems being developed, such as the four dimensional variable data assimilation system (4D-Var) and the Space and Time Mesoscale Analysis System (STMAS) and which utilize all available observations; will provide higher-resolution input to fire danger maps.</p> <p>The State of Florida is the first state to use NOAA’s Automated Surface Observation System (ASOS) historical and current data to generate NFDRS outputs. No other state or local area has this capability.</p> <p>The NWS is working with the USFS Missoula Fire Lab to utilize the NWS National Digital Data Base (NDFD) to incorporate gridded data into daily NFDRS products. The Scripps Institute can utilize the Missoula work.</p>	<p>Emerging NOAA 4D Data Cube development (NextGen) will allow the extraction of observations and model fields to provide a consistent data source for fire weather operations and research.</p> <p>Potential collaborative research activities are currently being considered among NOAA/OAR, NOAA/Geophysical Fluid Dynamics Laboratory (GFSL), NWS/NCEP, the USFS Fire Laboratories and universities for collaborative research to improve the regional seasonal climate forecast used in the NFDRS. Efforts will be made to expand use of ASOS data to generate fire danger information nationally.</p> <p>The Desert Research Institute (DRI) is also performing research on the validity and usefulness of NOAA observations and alternative observation networks to calculate fire danger values. The research is expected to assist in validating the use of alternative fire danger observation networks.</p>

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<p><b>Finding #6:</b> The USFS underutilizes NWS forecasts in its generation of fire danger forecasts. For example, with the exception of data available from NOAA’s NDFD, gridded weather forecasts are not used, and next day forecasts are created via a simple interpolation scheme, which can introduce large forecast error.</p>	<p><b>Recommendations accepted.</b> Using existing resources, immediate potential exists to improve and expand the use of NDFD data to enhance fire danger assessments.</p>	<p>Experimental, gridded fire danger maps are already being produced in concert with the USFS Research Station in Missoula, MT. This effort can be the basis of expanding NDFD-derived fire danger at higher/longer temporal scales.</p> <p>NOAA Programs that can be leveraged for future high-resolution data availability include NextGen, AWIPS II and the resulting web-enabled NOAA data.</p>
<p><b>Finding #6 Recommendations:</b></p> <p><b>6.1:</b> Use NCEP forecasts with all systems that require NOAA weather data to generate short- to long-term fire weather and fire danger forecast maps to meet the different spatial scale needs of federal state and local fire managers.</p> <p><b>6.2:</b> Make these products available through a web-based GIS platform for users to customize fire weather and fire danger maps to suit their spatial and temporal scale of interest.</p> <p><b>6.3:</b> Develop training plans and packages with the National Wildfire Coordinating Group (NWCG) to familiarize users with the forecast technology.</p>	<p>Efforts are advancing rapidly in this area through the Missoula Fire Lab and experimental products are being produced in collaboration with NOAA.</p> <p>GIS and web-enabled data distribution and visualization technologies are under development at ESRL. These technologies are AWIPS II compatible.</p>	<p>As part of ongoing efforts at NCEP and ESRL, NOAA advances in probabilistic and ensemble forecast output will be made available to USFS fire labs to inform development of improved fire danger forecasting and to ongoing ensemble modeling research. Solar radiation parameters are a part of current model output. Given the resources, research should also move beyond the surface, to include vertical atmospheric assessments of potential fire behavior.</p> <p>Funding to facilitate training development is already being provided to the University Corporation for Atmospheric Research’s Cooperative Program for Operational Meteorology, Education and Training (UCAR/COMET) from NWS, in partnership with NWCG and NSF. The funding by 2010 will produce the first interagency fire weather/fire behavior training course accepted by NWCG. This is a first step in designing an interagency, complete fire weather curriculum.</p>
<p><b>Finding #7:</b> Long term fire potential outlooks produced by the National Interagency Fire Center’s (NIFC) Predictive Services Program neither incorporate forecast uncertainty nor utilize ensemble forecasts for this purpose.</p>	<p><b>Recommendations accepted.</b> NCEP’s Climate Prediction Center (CPC) and NOAA National Climatic Data Center (NCDC) forecasts are reviewed each month by the fire weather community as part of coordination with the National Interagency Coordination Center (NICC).</p>	<p>The Federal Fire Agencies, CPC, NOAA NCDC, and NOAA PSD research will continue to partner with Predictive Services to improve the fire potential assessment process.</p>
<p><b>Finding #7 Recommendations:</b></p> <p><b>7.1:</b> Utilize ensemble forecasts to develop seasonal to inter-annual fire weather and fire danger maps.</p>	<p>NOAA’s CPC and Climate Diagnostics Center (CDC) are already serving as a source of weather and climate forecasts. There are also two</p>	<p>Basic research should be conducted by CPC to extend current, seasonal forecast techniques for precipitation and temperature to include seasonal,</p>

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<p><b>7.2:</b> Provide a source of weather/ climate forecasts for annual fire potential forecasts.</p> <p><b>7.3:</b> Encourage further research and development of seasonal climate-related fire forecasts to meet strategic fire planning needs.</p>	<p>in-person workshops with direct NCEP and CDC involvement each year to produce two, widely disseminated national fire potential outlooks.</p> <p>Using OAR Climate Program funding, NOAA/ESRL/PSD has partnered with USFS to conduct preliminary research to determine the effects of ocean climate changes on regional fuel conditions. These effects could impact fuels characterization which would result in an improved Energy Release Component (ERC) value.</p>	<p>average development of climatologies, bias correction, climate mode composites, and verification of ensemble model forecasts of relevant parameters. This would need to be viewed as a long-term objective with no presumption of future useable skill.</p> <p>NOAA will utilize external partnerships and leverage funding opportunities to fund research on the effect of climate on seasonal fuels characterization. DRI will be a valued partner.</p> <p>The NICC/CPC/NCDC partnership can be expanded to other agencies. Also, identifying resources to develop tools and services as outlined in Recommendation 7.1 would support this partnership and others, [e.g., with NOAA’s Climate Program, and the National Integrated Drought Index System (NIDIS)].</p>
<p><b>Finding #8:</b> Use of climatology beyond a few days ignores the potential contribution of NOAA medium-range numerical forecasts and averages conditions that can obscure special circumstances that could foretell exceptional fire behavior.</p>	<p><b>Recommendation accepted.</b></p> <p>Some NOAA Weather Forecast Offices (WFOs) have developed local forecast tools which integrate local observations and account for local topography to improve medium range forecast products.</p> <p>However, progress must be made to develop forecast products out to a month in advance.</p>	<p>NOAA collaborative research with CPC, universities and JFSP have provided products used in annual seasonal assessments of fire. It is anticipated that these collaborations will continue. Additional resources will be needed to validate these products and implement an operational version of them.</p>
<p><b>Finding #8 Recommendations:</b></p> <p><b>8.1:</b> Develop a standardized “intelligent assistant” or decision support tool for NOAA forecasters (including IMETs) who support Incident Commanders with weather information.</p> <p><b>8.2:</b> Develop numerical prediction methods that provide a frequently updated sequence of misoscale and mesoscale forecasts to provide forecasters with the capability to anticipate extreme fire behavior with several hours notice.</p>	<p>Efforts are underway to tailor NWS fire program software systems and national web-based products to better utilize current forecast grids for supporting fire weather, marine incidents and hazardous spills. This is being done through provision of point forecast data and by redesigning the NWS Spot program interface. The Spot program support is on the front lines of providing an operational, real-time “intelligent assistant”. Limitations exist in full development of an intelligent assistant in terms of standardizing fire reporting practices and full development of a spectrum of validated landscape-scale models.</p> <p>However, an experimental, web-</p>	<p>NOAA’s Fire Weather Program will coordinate internally and will work with NWCG to validate requirements, to ensure they are incorporated for development in future software builds for the Advanced Weather Interactive Processing System II (AWIPS II).</p> <p>It is proposed that an Operational Proving Ground be established to validate tools and uncertainty information developed as a part of the fire weather research and operations programs. Internal and leveraged funding will be required to establish this inter-agency capability.</p> <p>The AWIPS II program can be leveraged to provide a platform for</p>

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	<p>addressable, 500-meter, moveable window, fire scale model was running in FY08 at NOAA/GSD for evaluation and use by industry and researchers. The GSD/NCEP High Resolution Rapid Refresh (HRRR) model provides hourly forecasts and will be used as a background model for fire weather research and NCEP high-resolution background fields.</p>	<p>tool development.</p> <p>A spectrum of validated models is necessary to provide frequent, real-time misoscale and mesoscale models. NOAA will be actively engaged in validating and transitioning available models into operations.</p>
<p><b>Finding # 9:</b> Lightning is the major natural ignition source for wildland fires, particularly “dry lightning”, which occurs with little or no rain. Consequently, improvement of NOAA’s Lightning Activity Level (LAL) index is required to better represent dry lightning cases. Also, problems with the current Lightning Detection system, (LDS) need to be identified and corrected.</p>	<p><b>Recommendations accepted.</b> NCEP’s Storm Prediction Center (SPC) has developed a statistical lightning climatology and prediction system that provides probability forecasts to determine areas where cloud to ground lightning flashes could threaten lives and property and start wildfires.</p>	<p>Lightning forecasting improvements are being made and will continue to be emphasized within NOAA, utilizing agency partnerships and experts at the SPC, universities and ESRL.</p>
<p><b>Finding #9 Recommendations:</b> <b>9.1:</b> Establish a national LDS, managed with full resources, coordinated under one agency, and with a more robust telemetry. Data collection should be centralized for the continental U.S. (including Alaska and Hawaii).</p> <p><b>9.2:</b> Develop and validate better forecasts of lightning activity that have improved representation of ignition potential. Consider partnering with Predictive Services to develop a new lightning probability product with a focus on dry lightning.</p>	<p>Algorithms developed by NOAA scientists help detect lightning strikes at night using low-light visible satellite data.</p> <p>Efforts are underway to provide experimental lightning output, combined with Predictive Services fuel dryness, on the SPC web site. In order to better forecast lightning we need a better understanding of interactions at the cloud scale.</p> <p>Funding from JFSP has facilitated the development of experimental, web-based products.</p>	<p>NOAA will ensure that all available lightning output will be included on NOAA’s emergency response web page plan.</p> <p>OAR and NWS must work with NCWG to identify requirements for, advocate and develop improved lightning prediction tools, including requirements for a national LDS. Improved fire-scale modeling efforts would aid this effort.</p> <p>NOAA and USFS scientists have secured JSFP funding to validate and improve lighting forecasts which incorporate lighting climatology, fuels information from Predictive Services and weather forecast data. The output should be experimentally available in 2010.</p>
<p><b>Finding #10:</b> Increased collaboration between NOAA, EPA and land management researchers would facilitate improvements to the fire and smoke modeling components which are necessary to quantify the emission rates and source areas for air pollutants of interest. Also, all smoke-related information should be made</p>	<p><b>Recommendations accepted.</b> NOAA has worked with USFS, EPA, and NASA in developing smoke prediction capabilities. NOAA’s operational smoke predictions, incorporating USFS fire emissions information, provide PM2.5 predictions from smoke as part of the National Air Quality Forecast Capability, built in partnership</p>	<p>Increased collaboration is required to ensure effective leveraging of resources among the entities cited in 10.3 to produce an improved and centralized suite of products that can be made accessible via a public web portal.</p>

Finding	Position and Progress	Plans and Partners
available from one source, as various models currently exist between USFS researchers and NOAA.	between NOAA and EPA.	
<p><b>Finding #10 Recommendations:</b></p> <p><b>10.1:</b> Continue to leverage research capabilities to help improve representation of smoke plumes from wildland fires in operational forecast tools through ongoing collaborations with NOAA, EPA and USFS researchers.</p> <p><b>10.2:</b> Encourage WFO forecasters and IMETs to take an appropriate smoke management course to gain familiarity with the fuel consumption and smoke emissions tools used by land managers.</p> <p><b>10.3:</b> Work with NIFC, researchers from the USFS and EPA, and state and local environmental and public health agencies, to ensure complete smoke and pollution information is gathered, processed, summarized and made available to the public in a timely and easily accessible manner.</p>	<p>NOAA provides an operational smoke guidance product for CONUS and Alaska via its weather.gov web site, with experimental test products extended to Hawaii available on weather.gov/aq-expr. Research and development is in progress on extending the smoke product to Hawaii and integrating smoke with comprehensive air quality models.</p> <p>DRI and USFS’ Fire Consortium for the Advanced Modeling of Meteorology and Smoke have collaborated on a national smoke guidance product.</p>	<p>It is proposed that NOAA begin research activities to evaluate experimental smoke dispersion and plume rise algorithms along with fire weather and fire behavior models. Research will utilize tracer studies and field study observations. This is part of fire-scale weather modeling research. NOAA will work closely with its partners in developing its advanced air quality modeling capabilities.</p> <p>NOAA’s Fire Weather Program will research and identify an appropriate smoke management course for IMETs.</p> <p>The fire weather test bed, as described below in Finding 18, can be leveraged to support public products and information delivery development.</p> <p>The JSFP has provided FY10 funding to USFS researchers to develop a long-term smoke science plan. NOAA has agreed to participate in this process as a part of this program.</p>
<p><b>Finding #11:</b> Fire weather forecast validation information, including “spot forecasts” produced by IMETs, is not currently available to the land management agencies. Validation should be a routine part of all fire weather forecasts. Also, IMET forecasts should be disseminated via NOAA web and data-serving capabilities.</p>	<p><b>Recommendations accepted.</b></p> <p>Traditional Spot forecasts are distributed to users upon request for specific lat/lons from NWS WFO’s.</p> <p>IMET Spot forecasts in the field take on multiple formats for specific, fire-scale operations. While these forecasts can be disseminated, it must be understood that IMET Spot forecasts are highly specialized for use directly by the local Incident Command Team.</p>	<p>Field studies are needed to validate Spot forecasts. The fall 2009 JFSP call for research topics specifically is requesting proposals to validate fire weather forecasts. Several proposals are expected to be submitted to help validate fire weather forecasts</p> <p>Tools to provide web-based Spot forecasts will continue to be developed.</p>
<p><b>Finding #11 Recommendations:</b></p> <p><b>11.1:</b> Disseminate IMET Spot forecasts from the field via NOAA web and data-serving capabilities and consider providing automated email distribution and notification of Spot forecast availability as is</p>	<p>NOAA’s Fire Weather Program will work with the NWS Office of the Chief Information Officer to determine requirements and any needed resources to make Spot forecasts generally available via the web or other appropriate centralized</p>	<p>IMET Spot forecasts will be posted to a centralized database and posted where land management agencies can view the product via the web.</p> <p>The AWIPS II and NextGen programs can be used to leverage web-enabled</p>

Finding	Position and Progress	Plans and Partners
<p>done with NOAA’s National Hurricane Center products.</p> <p><b>11.2:</b> Provide fire weather forecast verification and validation information and include performance standards for each forecast element. Include spatial verification information and spot and IMET forecast validation information in final documentation for all major incidents.</p>	<p>repositories, and to examine options for email and other automated notification of their availability.</p> <p>NWS will also work internally to propose verification and validation techniques for key fire weather forecast elements. Resources to support recommended activities will be identified as needed.</p>	<p>tools and data access needed to provide IMETs with tools to issue web Spot forecasts in the future.</p> <p>NOAA will coordinate with NWCG to make progress on validating fire forecasts, especially at the fire scene.</p> <p>Resources are needed for field studies in this area and can be combined with observing systems and model verification field studies. The JFSP may fund these efforts, given a well-written proposal. Proposals will also be submitted to the NOAA Programming and Planning process.</p>
<p><b>Finding #12:</b> Additional tools and technologies are needed to improve and maintain communications and to transfer weather-related data between WFOs, IMETs and fire managers.</p>	<p><b>Recommendation accepted.</b> OAR’s ESRL has utilized various data delivery and data compression techniques to deliver data to the existing system used by NWS IMETs and land management agencies.</p>	<p>NOAA must utilize leveraged funding opportunities to support development of nationally-implementable, improved fire weather data delivery, decision support or visualization tools.</p>
<p><b>Finding #12 Recommendation:</b> <b>12.1:</b> Explore emerging communication formats and low-bandwidth technologies to allow fire managers to access site data, and to receive spot forecasts and extended nowcasts. Emphasize maximizing capabilities of current low-bandwidth devices such as iPhones and Blackberries.</p>	<p>ESRL/GSD has developed compression and grid extraction technologies to improve distribution of gridded forecast data. This technology has been used by Predictive Services meteorologists for 4 years to ingest gridded forecast data and as input to their fire potential algorithms. The FX-Net system, which facilitates transmission of live data to IMETs at fire scenes, has used these compression algorithms for over 5 years. Also, NWS developers have prototyped various distribution solutions to allow wireless cell receivers access to existing NWS forecast products.</p>	<p>NOAA has already leveraged the NDFD web-enabled data to provide gridded data to external agencies.</p> <p>GIS systems are widely used by Land management and NWS agencies today.</p> <p>Emerging NWS web-based and GIS-enabled tools can be used to add fire information which is then made available via low-bandwidth technology, such as cell systems. In order to continue to provide full NOAA data sets to the IMETs, the AWIPS II Thin Client and web-enabled data delivery systems should be leveraged.</p>
<p><b>Finding #13:</b> WFO forecasters and deployed IMETs need 3-D visualization of terrain-following weather, fire perimeter, and other data keyed to wind and relative humidity which are critical to fire weather monitoring and forecasting. Common GIS tools such as Google Earth can be adapted to integrate operational weather data.</p>	<p><b>Recommendations accepted.</b> Progress is being made by leveraging research and development work from the AWIPS II extended research projects.</p>	<p>NOAA must leverage funding opportunities to develop improved GIS and 3D visualization tools for application beyond fire weather needs.</p>

Finding	Position and Progress	Plans and Partners
<p><b><u>Finding #13 Recommendations:</u></b></p> <p><b>13.1:</b> Develop and deploy improved 3-D weather visualization tools for use by Predictive Services, WFO forecasters and IMETs for decision making, forecasting and briefings.</p> <p><b>13.2:</b> Make fire weather products available through a web-based GIS platform for users to produce their own customized fire weather and fire danger maps to suit their spatial and temporal scales of interest.</p> <p><b>13.3:</b> Ensure NOAA data and forecast products are compatible with official, Fire Agency-endorsed planning tools as the Wildland Fire Decision Support System (WFDSS).</p>	<p>In collaboration with NWS, ESRL/GSD has identified data delivery, thin client and collaboration tools which may be evaluated for transition from research to operations. Fire weather decision support and visualization tools and requirements analysis is taking place through GSD, NWCG and the IMET Program.</p> <p>Gridded data are extracted from the AWIPS Gridded FX-Net data base using the web-based, Grid Extraction Tool (GET).</p> <p>GIS systems utilizing NOAA weather data are being developed at USFS research stations and laboratories.</p> <p>Research being conducted at GSD includes the use of the 4D Data Cube.</p> <p>Certain NDFD data are already available to the WFDSS end-user. This was done via establishing direct contact with the WFDSS Fire Agency.</p>	<p>Leverage AWIPS II and NextGen programs to provide web-enabled data GIS tool sets. Collaborate with IMETs, ESRL/GSD and NWCG to identify tools and information needed by forecasters to provide operationally useful information to fire incident commanders, emergency managers and the public.</p> <p>Utilize an Operational Proving Ground and social scientists to validate use of tools and value of information provided.</p> <p>Some additional resources will be needed to leverage these systems to provide weather information specific to fire incident stakeholders.</p> <p>WFDSS, a USFS incident planning tool, is in the process of being officially adopted by the Bureau of Land Management. Direct contact will be made with the WFDSS development team to assure NOAA data is accessible and in a format necessary to populate the WFDSS weather planning form locations.</p>
<p><b><u>Finding #14:</u></b> The thin client data provision capability to IMETs currently provided by GSD’s data delivery software called “FX-Net” is critical to ensure IMET access to needed observational and forecast data sets at fire scenes.</p>	<p><b><u>Recommendation accepted.</u></b></p> <p>Continued provision of support for the FX-Net data system is critical to ensure operational data flow to IMETs at fire scenes.</p>	<p>IMET onsite support efforts would fail without FX-Net/Thin Client capability. FX-Net is the IMET lifeline to NOAA data.</p>
<p><b><u>Finding #14 Recommendation:</u></b></p> <p><b>14.1:</b> Ensure availability of live weather data via the current “FX-Net” interface, and subsequently the AWIPS thin client, to facilitate IMET support at fires.</p>	<p>The NWS Fire Weather Program budget is providing funding for GSD maintenance of the FX-Net software until this functionality is baselined via AWIPS II transition programs.</p>	<p>AWIPS II plans state there will be a thin client capability for IMETs in FY12. NOAA will continue funding FX-Net hardware and software needs until this capability is fielded.</p>
<p><b><u>Finding #15:</u></b> The joint NOAA-USGS Debris Flow Project is an excellent illustration of interagency collaboration on a pressing multidisciplinary problem.</p>	<p><b><u>Recommendations accepted.</u></b></p> <p>Debris flow is a key concern in fire scarred areas.</p>	<p>NOAA will continue to partner with USGS, and the USFS to monitor debris flow at the 2009 Station Fire in southern California.</p>

Finding	Position and Progress	Plans and Partners
<p><b><u>Finding #15 Recommendations:</u></b>  <b>15.1:</b> Continue, in collaboration with USGS, to develop thresholds of rainfall rates and totals for public warnings of impending debris flows.</p> <p><b>15.2:</b> Continue to work with USGS on national implementation, but refine the concept of operations to minimize the handling of the data, the forecast and the warning.</p>	<p>During 2008, threshold development work for rainfall rates and rainfall totals in southern California continued, and thresholds were developed to cover the burned areas near Big Sur, CA. The pilot system now operates over the areas of responsibility for WFOs in Monterey, Oxnard, and San Diego, CA.</p> <p>The debris flow warning plan encourages USGS to continue development of more advanced debris flow models that do not rely on empirical threshold values.</p>	<p>The original plan called for the models to be operated at USGS with precipitation observations and forecasts provided by NWS but the modified concept now encourages USGS to develop and calibrate the models and the parameters. However, the models will be run at NWS WFOs, thus minimizing the flow of information between the two agencies, and eliminating the need for the USGS to set up the 24/7 warning operation.</p> <p>NIST and the USFS evaluate burned areas and provide burned fuels information back to the USFS to aid in the NOAA/USGS evaluation and monitoring work. This work will continue at the site of the Station Fire during the winter of 2009-10. Local WFO efforts, such as those in the San Diego, Monterey and Oxnard WFOs, will assist in the development of debris flow monitoring and warnings.</p>
<p><b><u>Finding #16:</u></b> Climatic impacts, coupled with demographic, population density, and economic trends leading to continued growth around major urban areas suggest that vulnerability to wildfire will continue to increase for the foreseeable future. There is a need to consider this increasing vulnerability as part of climatic impact assessments.</p>	<p><b><u>Recommendations accepted.</u></b>  Significant research is available on potential climate impacts to fire occurrence, through partners at DRI.</p> <p>However, significant research is still needed to improve the outlooks, downscale for local effects/topography and indentify the impact on values at risk.</p>	<p>Additional research is needed to utilize climate research from OAR/CMD and to integrate fire danger algorithms and data from the NIDIS system.</p> <p>Additional resources may be requested to expand upon previous work done at DRI.</p>
<p><b><u>Finding #16 Recommendations:</u></b>  <b>16.1:</b> Use our climate modeling capabilities to better understand the role of fires in the climate system, anticipate and prepare for increased threat from fire in the future and, at the regional scale, assess propensity for increased fire hazard as the global temperature warms and wind and relative humidity patterns change.</p> <p><b>16.2:</b> Use fire detections from NOAA’s operational environmental satellites to develop a large scale climate record.</p>	<p>For 16.1, CPC and GFDL will collaborate to identify climate parameters that lead to increased threat of fires and to develop future scenarios based on climate change scenarios. NOAA will work with social scientists to identify the socio-economic factors of climate change that contribute to increased vulnerability to fires.</p> <p>NCEP’s Global Forecasting System 384-hr forecast model is used by NIFC Predictive Services to build long range fire potential maps. Data are accessed via a web portal from the</p>	<p>There is ongoing work to link fire occurrence to climate patterns at SCRIPS and DRI as funded by land management grants and agreements</p> <p>NOAA researchers will investigate decision support requirements for climate risk management, development of new tools and methodologies to enhance climate risk management, and application of social sciences across NOAA regions to improve climate and weather risk perception, communication and management actions.</p>

Finding	Position and Progress	Plans and Partners
	<p>AWIPS data base using the ESRL/GSD Gridded Extract Tool (GET).</p> <p>A plan and strategy for addressing 16.2 should be jointly coordinated by NESDIS and CPC given sufficient allocation of computer resources. A potential strategy is for CPC to work with NESDIS to develop a long-term fire climatology. NESDIS would maintain/store necessary input data.</p>	<p>NOAA will expand the GET tool to allow access to a gridded climate data record.</p>
<p><b>Finding #17:</b> Many nations around the world, including the U.S., need operational fire weather support to manage fires within their boundaries or within regional consortia through which they share fire management resources. NOAA should develop and formalize exchanges of operational and research personnel.</p>	<p><b>Recommendations accepted:</b> A robust exchange has been underway with Australia for the past three Australian and U.S. fire seasons.</p>	<p>NOAA is exploring the opportunity to extend outreach to other countries by continuing collaborations with NIFC and the NWCG as well as other international fire agencies and research groups.</p>
<p><b>Finding #17 Recommendations:</b> <b>17.1:</b> Develop and formalize exchanges of operational and research personnel, to share knowledge about weather and climate aspects of wildland fire management and incorporate this knowledge into NOAA research and operations. <b>17.2:</b> Explore with other countries opportunities to collaborate on prescribed burns as experimental fires to test new tools, models and techniques under real-world conditions.</p>	<p>In each of these seasons, Aussie fire weather forecasters have learned about and supported WFO operations during U.S. fire seasons, and also participated and presented in the 2008 IMET workshop. Similarly, NOAA IMETs have supported Australian forecast centers and, this year, provided support with their newly implemented version of NOAA's gridded forecast software.</p> <p>This highly successful exchange should continue.</p>	<p>The NWS Director and Director Ayers (from the Australia Bureau of Meteorology) will be meeting in December of 2009 to discuss continuation of the international partnership between Australia and the U.S. Fire weather is one of five sub-categories in the exchange.</p> <p>Begin interaction with the Canadian Interagency Forest Fire Center (CIFFC) to explore science and technology exchange with their fire weather and behavior research and operations programs.</p>
<p><b>Finding #18:</b> The provision of NOAA's high-quality fire weather services should be highlighted as a core element within NOAA and should be cited explicitly in NOAA's and NWS' Strategic Plans. NOAA also needs to establish a clear fire research focus and test bed.</p>	<p><b>Recommendations accepted.</b> Partnerships with NOAA's research and operations partners and stakeholders in establishing test beds and a research focus is essential to the success of fire weather services improvement.</p>	<p>NOAA will work internally to develop appropriate language within its strategic planning documents to highlight NOAA's commitment to fire weather services.</p> <p>The establishment of a test bed to include fire-related climate, weather forecasting and observations archive for research, validation and evaluation is critical to improving NOAA's fire weather services.</p>

Finding	Position and Progress	Plans and Partners
<p><b><u>Finding #18 Recommendations:</u></b>  <b>18.1:</b> Increase focus on NOAA’s fire weather support in the next update of its Strategic Plan, making fire weather a higher priority and seeking additional authorization and funding as needed.</p> <p><b>18.2:</b> Designate a research laboratory to head its fire weather-related research and development efforts and provide it with appropriate budget and authority.</p> <p><b>18.3:</b> Work with federal fire agencies and other members of NWCG to establish a fire weather test bed, select a location for it and determine a strategy to leverage funding to build and staff it.</p> <p><b>18.4:</b> Institutionalize the local “Fire Season” giving it the same priority and emphasis as “severe convective weather season”, “hurricane season” and “winter weather season.”</p> <p><b>18.5:</b> Provide enhanced support for fire weather forecasting in WFOs and IMET operations, including funding for training, necessary equipment maintenance and replacement, and current and future communications.</p>	<p>The NWS Fire Weather Program is working with the NWS Strategic Planning and Policy Office to develop language for NOAA’s updated Strategic Plan and will also include similar language in the soon-to-be updated NWS Strategic Plan.</p> <p>NOAA will consider options for establishment of the fire weather research focus and fire weather test bed as part of the ongoing OFCM process to develop a framework for action as identified in the Introduction. NWCG should be included as a full partner in the coordination process.</p>	<p>NOAA will further analyze the need for a central fire weather research and development laboratory as stated in recommendation 18.2, with the intent to establish a lab similar to NOAA’s National Severe Storms Laboratory and Hurricane Research Division. In addition, NOAA recommends the establishment of a fire-scale weather test bed to support research to operations transition and the archive of fire environment data needed to research and validate experimental models. Also, an appropriate Fire Weather Research focal point to support research-related fire weather submissions should be identified within NOAA.</p> <p>NWS plans to coordinate a “Fire Weather Awareness Week” to coincide with the usual start of the fire season in late spring FY 10.</p> <p>Needed support for fire weather forecasting and IMET operations is funded from the NWS Fire Program.</p>
<p><b><u>Finding #19:</u></b> NOAA must interact with a large number of fire weather entities to support and execute a fire weather research agenda. Given the modest resources NOAA has available in this area, it is challenged to be open, adaptable, and flexible in its approach to the several federal wildland management agencies and the university community. It must define its unique roles in fire weather research, avoiding overlap and direct competition with other agencies, and leveraging the work done by others.</p>	<p><b><u>Recommendations accepted.</u></b>  While legislative authority for NOAA’s fire weather services is already granted by the Organic Act, NOAA should work with other fire research entities to clearly define its supporting role with regard to research-to-operations transition activities. Such a definition can be supported via establishment of a clear research focus and via participation in a multi-agency test bed per Finding #18.</p>	<p>NOAA participates with fire agencies and land management groups in the U.S. and internationally. To allow for effect collaborations and to move research and emerging technologies to operations, a collaborative, Joint Fire Weather Research Program must be established with NOAA as a full participant.</p> <p>NOAA must also continue its close collaboration with NWCG.</p> <p>An interagency Agreement should be established between Federal Fire Agencies and NOAA OAR concerning fire weather research responsibilities.</p>

Finding	Position and Progress	Plans and Partners
<p><b><u>Finding #19 Recommendations</u></b></p> <p><b>19.1:</b> NOAA should clearly identify its unique niches in operations and research in the fire weather area. Where necessary, it should seek appropriate legislative authority from Congress.</p> <p><b>19.2 :</b> NOAA should commission a survey of fire weather related research underway nationwide to identify potential leveraging opportunities.</p> <p><b>19.3:</b> NOAA should establish formal but flexible partnerships with research organizations in the federal wildland management agencies and the university community to develop new products and services, especially in modeling and new aerial observing system development.</p>	<p>No formal action has yet been taken to study fire weather research underway nationwide, although NOAA is already coordinating with USFS research, NIST, NCAR, DRI and the university community on fire weather research projects. NOAA has an MOA with NIST to focus collaborative research on coupling weather and fire behavior models. NOAA is also partnering with the university community, NIST and the USFS on utilizing UAS, and other mobile observing systems such as mobile radar, sited lidar and mobile observation systems.</p>	<p>Once a NOAA fire weather research focus and an interagency test bed are established, a plan for a nationwide survey can be developed, along with a development plan for needed, new products and services.</p> <p>An established NOAA fire weather research group would work with partners and collaborators to identify gaps in resources to complete research required. Resources to fill these gaps can then be identified along with our research partners.</p>

#### **4. Next Steps**

As stated in the Introduction, NOAA has been working on a number of fronts to assess user needs associated with its Fire Weather Program. In addition to the effort cited in this report, OFCM is developing a “framework for action” based on the findings and recommendations of this report and the results of its 2006 survey. The NOAA Fire Weather Program, in collaboration with participating members of the OFCM Fire Weather Working Group (including NOAA’s land management partners) will participate in the development of this framework, to be completed this year. The OFCM effort may result in the need to clarify or refine the strategies outlined in Section 3 with regard to the recommendations, and an update to this report will be issued as needed once the OFCM effort has been completed.

NOAA researchers continue to collaborate with their research and operations partners to pool resources, and collaborate on JSFP, NSF and other proposals to obtain funding to investigate identified research gaps. Private industry expertise can be leveraged as well, specifically to provide research on fire spread and enhance fire behavior projections for management decisions.

Overall, both NOAA and its land management partners have responsibility for gathering fire observations. NOAA has a clear role to run and improve its weather and smoke models, and to provide these data in needed formats to run fire behavior models, inform fire management and suppression decision support systems, and provide clear, useful information to emergency managers and the public. The agency’s land management partners are responsible for leading the integration of NOAA weather data, forecasts and algorithms into models designed to forecast fire behavior at the scales needed to support fire management decision-making. NOAA OAR expertise should be integrated into the development of the fire behavior models as well. As stated throughout this document, success with many of these efforts will depend upon fully leveraging all entities with a stake in fire weather and fire behavior improvements. The proposed, new collaborative activities cited in Findings 18 and 19 are key in this regard.

NOAA appreciates the work of the SAB and its Fire Weather Research Working Group, which dedicated a great deal of time and energy towards creation of the report. The agency will continue to work with the Board to report progress and efforts to implement the recommendations of the fire weather report in the future.

## **Appendix: NOAA Research, Collaborations and Conferences**

The following is a summary of ongoing collaborative activities between NOAA, other agencies and universities with an interest in fire weather research:

### **JFSP Research Proposals (funded and proposed):**

Implementation of a climate-vegetation based early warning and prediction system for interagency fuels management – 2005.

Principal Investigator: Dr. Timothy J. Brown, Desert Research Institute

Co-Principal Investigator: Dominique M. Bachelet, Oregon State University

Co-Principal Investigator: Robert S. Webb, NOAA Climate Diagnostics Center

Collaborator: Paul M. Schlobohm, Bureau of Land Management

Predicting Lightning Risk Nationwide – 2007

Principal Investigator: Miriam L. Rorig, USFS Pacific Northwest Research Station

Co-Principal Investigator: Dr. Phillip Bothwell, NOAA Storm Prediction Center

Models for fire spread in the wildland-urban interface – 2008

Co-Principal Investigator: Glenn Forney, NIST

Co-Principal Investigator: Ronald Rehm, NIST

Collaborator: Ruddy Mell, NIST

2009 JFSP Request for Applications - November 2009:

The JFSP is requesting proposals, “that investigate and quantify the accuracy and reliability of fire weather forecasts, and that develop new analysis techniques to improve forecast accuracy.”

### **NOAA Fire Weather Research Collaborations:**

2009: NOAA and NIST MOA to collaborate on weather and fire behavior model integration and coupling. NOAA’s task is to down-scale the weather model to sub-1Km scale for use by the behavior models to forecast the spread of fires. NIST will identify fire behavior dynamics to integrate into weather models to forecast the effects of fire on the weather.

2006, 2007, 2009, NOAA, University of Colorado, NIST, USFS proposal to JSFP to sense the fire environment and validate weather models over fires in complex terrain.

2009 Fall JSFP call for proposals, highlighting fire weather model performance and verification. NOAA will likely submit several proposals designated to improve fire weather forecast model performance and verification.

The 2009 Savannah, Georgia 4<sup>th</sup> International Fire Ecology Congress will present an opportunity to collaborate on fire scale observation strategy, with links to fire scale model verification. A second Workshop will result involving NOAA OAR and USFS research to discuss UAS and other observation platform use on fires.

NOAA/OAR, NOAA/NCEP technical interchange to develop a research and operations plan for providing meso-scale weather forecasts that will allow for the downscaling to fire-scale models.

NOAA Climate Prediction Center: CLIMAS workshops cooperative with the National Interagency Coordination Center to develop seasonal fire potential assessments.

NOAA/ARL and NOAA/NWS to produce real-time smoke products and an interactive smoke dispersion model (Hysplit).

NOAA/ESRL and the University of Argentina to collaborate on research to develop experimental plume rise algorithms for the Rapid Refresh WRF/Chem/Smoke model.

**Conferences Involving NOAA Fire Weather Leadership and Participation:**

2002, 2007 and 2009: AMS Fire and Forest Meteorology Conference

2006: National Wildland/Urban Interface Fire Education Conference

2006: 3rd International Fire Ecology Management Congress

2006, 2007: EastFire Conference

2007: American Institute of Aeronautics and Astronautics

2007: AMS Interactive Information and Processing Systems

2006, 2010: National AMS Conference

2009: NWS Eastern Region Fire Weather Workshop

Annually: National Seasonal Fire Weather Assessment Workshops