Joint Fire Science Program

Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

The OK-FIRE Website provides Oklahoma wildland fire managers with the most recent and forecasted fire weather, fire danger, and smoke dispersion information.

OK-FIRE: Weather-Based Decision Support for Wildland Fire Management

Summary

There's a lot of wildland in Oklahoma—and as a result, a lot of potential for fire. To help prepare for wildfire and perform fire management activities, land managers previously used weather, fire danger, and smoke management products provided by the Oklahoma Mesonet, the state's automated weather station network. But unfortunately, the products were not easily found or easy to use, and very little user training was provided. Fire managers also expressed the need for multi-day forecasting capabilities to help anticipate periods of high fire danger and severe wildfire conditions and to improve pre-burn planning and management. These critical needs were also affirmed in a problem statement provided by the Forest Service, which included a specific request for a forecast component integrated with the Mesonet-based fire management tools, the development of a dedicated, stand-alone fire management Website, and subsequent user training. Over the past five years, scientists at Oklahoma State University and members of the technology group of the Oklahoma Mesonet in Norman worked together to develop OK-FIRE, an integrated, easy-to-use operational system for wildland fire management. A true success story, OK-FIRE continues to evolve, with growing numbers and variety of users, almost 20 million Website hits in 2010, and regular training workshops. Even more important is the fact that OK-FIRE is helping to pave the way for other states looking to build a comprehensive weather-based wildland fire management system.

Steve Sanders, of the U.S. Army Corps of Engineers, stated, "I have a great deal of experience with prescribed fires, but even with all my experience I won't consider burning before using the information that is now available to us. It removes much of what used to be at best an educated guess. Thanks very much for providing us with such an effective tool. The OK-FIRE system is just as important as a drip torch and backpack fire pumps."

Fire on the plains

Oklahoma has approximately 22 million acres of wildlands. Each year, nearly 2.5 million acres burn by either wildfire or prescribed fire, with up to 90 percent burned by prescribed fire. Despite this, wildfires still have the potential to consume a significant amount of acreage during severe fire seasons.

Previously, Oklahoma wildland fire managers would access weather, fire danger, and smoke management products via Websites of the state's automated weather station network, the Oklahoma Mesonet. While helpful, these products were scattered and difficult to find. Also, there was no forecast component integrated with the weather and fire danger products and virtually no user training.

It became apparent that wildland fire managers needed a more integrated, user-friendly tool that could provide access to weather, fire danger, and smoke management products in one location. Further, managers expressed the need for multi-day forecasting capabilities, to help them better anticipate periods of high fire danger and severe wildfire conditions and to perform prescribed burning.

Three goals

To respond to the above needs, scientists at Oklahoma State University and members of the technology group of the Oklahoma Mesonet began working together to build a weather-based, operational wildland fire management system. The specific project goals included:

- The development of a comprehensive suite of recent, current, and forecast products for fire weather, fire danger, and smoke dispersion.
- The use of a dedicated, easily accessible Website to act as the delivery mechanism.
- Providing regional user training and customer support.

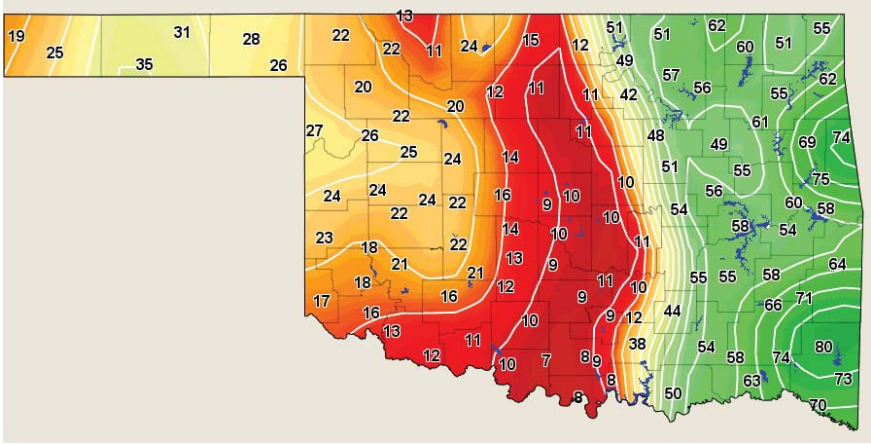
A pre-existing foundation

Thankfully, many of the building blocks required to construct the weather-based decision support system already existed. The system, named OK-FIRE, includes the fire weather, fire danger, and smoke dispersion products that were developed over past years and implemented on the Oklahoma Mesonet. Operational since 1994, the Oklahoma Mesonet provides the observed weather data for the fire weather products up to the current time as well as input data for the fire danger and smoke dispersion models. Currently unrivaled in its network and capabilities, the Oklahoma Mesonet has 120 environmental monitoring stations reporting weather data every five minutes.

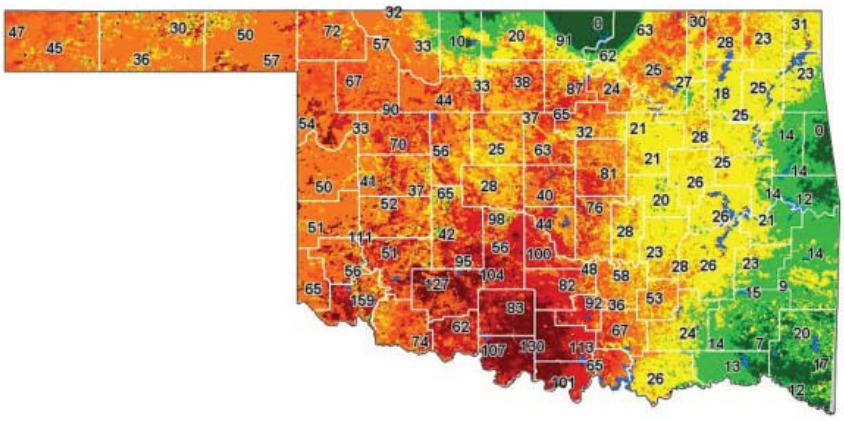
To provide the requested forecast component, 84-hour output from the North American Mesoscale (NAM) model was later integrated into the OK-FIRE system, allowing forecasts of fire weather, fire danger, and smoke dispersion up to three days in the future.

The Oklahoma Fire Danger Model (OKFD), used to assess fire danger conditions, was another building block incorporated into OK-FIRE. An implementation of the National Fire Danger Rating System (NFDRS) developed by the Forest Service, this model calculates four indices of fire danger, including burning index, spread component, energy release component, and ignition component. The OKFD model uses hourly Mesonet weather data as well as weekly satellite imagery to produce colored 1-km resolution maps of the four NFDRS indices. In addition, interpolated maps of 1-, 10-, 100-, and 1,000-hour dead fuel moisture and Keetch-Byram Drought Index (KBDI) are provided.

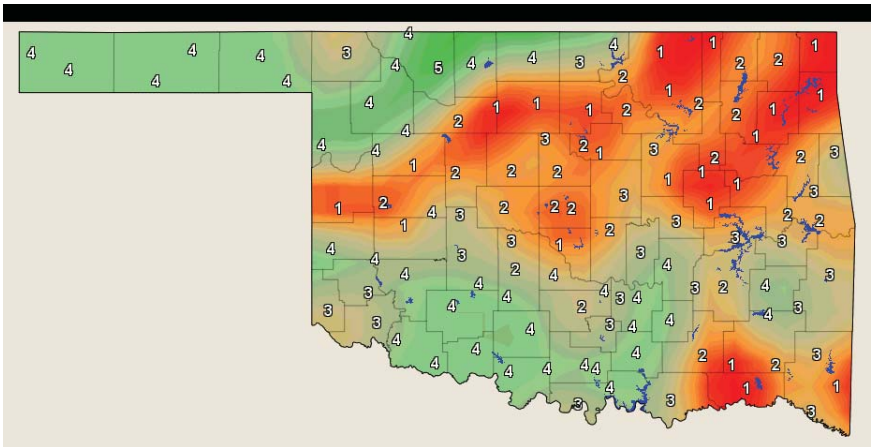
To calculate smoke dispersion, users can access the Oklahoma Dispersion Model. With this model, the atmosphere is broken into six categories of surface smoke dispersion, from excellent (6) to very poor (1). Smoke management is essential, especially for prescribed burn planning, as managers must ensure that smoke dispersion conditions are good (within categories 4-6) and that the smoke is not headed toward sensitive areas like homes or major roads.



Current fire weather conditions are easily accessible via OK-FIRE. Here is a map of relative humidity at 4 p.m. Central Daylight Time (CDT) on April 9, 2009, showing clearly the position of a strong dryline.



With just a few clicks, OK-FIRE users can access detailed maps highlighting the current statewide or site-specific fire danger conditions. This map shows the burning index at 4 p.m. CDT on April 9, 2009.



Using OK-FIRE, users can check current smoke dispersion conditions. Categories 4–6 (recommended) are represented by shades of green, and categories 1–2 (poor) are indicated by shades of orange and red. This dispersion map shows the conditions at 12 a.m. CDT on September 7, 2010.

To help users implement fire management prescriptions, OK-FIRE provides the Fire Prescription Planner. Based solely on the latest 84-hour NAM model, the planner offers a variety of variables for weather, fire, and dispersion and allows users to set upper and lower limits for each variable. Wind direction is also a prescription variable with eight wind direction sectors to choose from. A color-coded hourly forecast table is then produced which highlights the hours during which all the prescription parameters are met for the selected Mesonet location.

On the Web

The second project goal was to use a dedicated, easily accessible Website as the delivery mechanism for the suite of fire weather, fire danger, and smoke dispersion products. This goal was achieved in 2006 when the OK-FIRE Website was officially launched. Located at http://okfire.mesonet.org, the Website includes the weather, fire, and smoke products in map, chart, and table formats in addition to the following useful sections:

- Satellite and radar—provides regional and national imagery
- Air quality—supplies links to Websites that forecast national ozone and particulate matter concentrations

Fire Prescription Table for Skiatook

Disclaimer: *This forecast table, as with other OK-FIRE products, is based soley on output from the latest 84-h NAM forecast. As no weather forecast model is perfect, users are encouraged to check the official forecasts of the National Weather Service for consistency or discrepancies in the weather variable portion of this particular, consult the "National Weather Service" or "NWS Prescription Planner" links in the Weather/Forecasts section of the OK-FIRE web site.*

Change Prescription

Change Station

Date Time	Criteria Met?	RELH	WDIR	WSPD	Dispersion	1h DFM	10th DFM	TAIR	RAIN_1H	BI	IC	SC	ERC	KBDI
Nov 07, 2008 5:00 pm CST	No	35%	WNW	11 mph	4 (MG)	6%	9%	57°F	0.00 in.	16	12%	8	5	3
Nov 07, 2008 6:00 pm CST	No	37%	WNW	8 mph	2 (P)	6%	9%	55°F	0.00 in.	13	9%	5	5	3
Nov 07, 2008 7:00 pm CST	No	38%	WNW	7 mph	1 (VP)	7%	9%	54°F	0.00 in.	12	7%	4	5	3
Nov 07, 2008 8:00 pm CST	No	40%	WNW	6 mph	1 (VP)	7%	9%	52°F	0.00 in.	10	6%	3	5	3
Nov 07, 2008 9:00 pm CST	No	41%	W	5 mph	1 (VP)	7%	9%	51°F	0.00 in.	9	5%	2	5	3
Nov 07, 2008 10:00 pm CST	No	43%	W	5 mph	1 (VP)	7%	9%	50°F	0.00 in.	9	5%	2	5	3
Nov 07, 2008 11:00 pm CST	No	44%	W	5 mph	1 (VP)	8%	9%	49°F	0.00 in.	9	5%	2	4	3
Nov 08, 2008 12:00 am CST	No	46%	W	6 mph	1 (VP)	8%	9%	48°F	0.00 in.	10	5%	3	4	3
Nov 08, 2008 1:00 am CST	No	48%	W	6 mph	1 (VP)	8%	10%	46°F	0.00 in.	10	4%	3	4	3
Nov 08, 2008 2:00 am CST	No	50%	WNW	6 mph	1 (VP)	9%	10%	45°F	0.00 in.	10	4%	3	4	3
Nov 08, 2008 3:00 am CST	No	51%	WNW	6 mph	1 (VP)	9%	10%	44°F	0.00 in.	10	4%	3	4	3
Nov 08, 2008 4:00 am CST	No	53%	WNW	6 mph	1 (VP)	10%	10%	42°F	0.00 in.	10	4%	3	4	3

Users can better plan for prescribed burns with OK-FIRE's most popular product, the Fire Prescription Planner. Weather, fire, and smoke parameters can be set and a color-coded 84-hour forecast table will indicate specific times when the prescription is met.

- Burn site—provides links to road, topographical, and satellite/aerial maps
- Links—offers additional links to national/regional weather, fire, and climate/drought Websites

Initially, the OK-FIRE Website was password-protected and designed to serve a small but select group of users, specifically federal/state agencies and organizations with land management responsibilities in Oklahoma, including the Bureau of Indian Affairs, the National Park Service, the Forest Service, the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, Oklahoma Forestry Services, and The Nature Conservancy. As the system became more developed and recognized as reliable, developers removed the password restriction and opened the Website up to the general public in 2008. Today, there are a wide variety of OK-FIRE users, such as federal and state agencies, emergency managers, fire departments, and private landowners and organizations.

In the classroom

The third goal of this project was to provide regional training and customer support for OK-FIRE users. Since 2006, J.D. Carlson, principal investigator, has been conducting an annual series of fall training workshops and has taught up to 800 fire professionals to date. Through this training, users are able to become more familiar with the OK-FIRE Website and its capabilities, as well as ensure proper usage of the various products and information available.

J.D. Carlson leads one of many OK-FIRE training workshops. Credit: J.D. Carlson.

Mission accomplished

With the building blocks in place, a thriving Website, and supportive user training, the OK-FIRE project developers have met all goals and succeeded at developing a truly effective, state-of-the-art operational system for wildland fire management.

"The ingredients for success were numerous—including having a reliable automated weather station network, the Oklahoma Mesonet, to provide the infrastructure for actual weather data, having a dedicated team of workers both at Oklahoma State University and the University of Oklahoma, financial support, and offering training in computer workshops to develop a knowledgeable user base," stated Carlson.

Since its debut, usage of the OK-FIRE Website has skyrocketed. In 2009, Website hits increased 423 percent over 2008, along with a 310 percent increase in the number of unique visitors. In 2010, the average number of monthly Website visitors was up to 2,178 and overall Website hits were almost 20 million.

Carlson said, "As we opened OK-FIRE up to other user groups such as fire departments, emergency managers, and private landowners, the interest in and usefulness of OK-FIRE exploded. I continue to be amazed at all the different user groups out there that benefit from OK-FIRE."

OK-FIRE in action

Being able to look into the future can be a valuable capability, especially for wildland fire managers. With OK-FIRE, users can easily access the up-to-date information they need on fire and weather conditions, helping them better plan for and conduct prescribed burning. Steve Sanders, of the U.S. Army Corps of Engineers, stated, "I have a great deal of experience with prescribed fires, but even with all my experience I won't consider burning before using the information that is now available to us. It removes much of what used to be at best an educated guess. Thanks very much for providing us with such an effective tool. The OK-FIRE system is just as important as a drip torch and backpack fire pumps."

Chris Hise of The Nature Conservancy also commented, "I've attended several (NWCG) fire training courses lately with folks from around the U.S. and the OK-FIRE Website is by far the most informative and user-friendly fire danger forecast site I've seen. Great instruction, very thorough. OK-FIRE is the premiere Web-based fire information system in the U.S."

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For those who work in wildfire suppression, OK-FIRE provides the ability to track existing weather conditions during a wildfire, including future conditions critical for managing the fire. OK-FIRE can also provide guidance to counties on their burn ban decisions, as well as help users anticipate future periods of high fire danger so they can optimize staffing levels.

Larry Mullikin, former fire chief at the Stillwater Fire Deparment, stated, "The OK-FIRE system is a great tool for our community to use to determine when (actual time frames) to call additional personnel in to staff wildland firefighting trucks; give fire incident commanders an idea of fire control tactics which may, or may not, be effective, to alert community decision makers on the threat to Stillwater, and to warn the public of impending danger. We continue to use this technology to help us determine appropriate staffing levels, response procedures, and pre-fire planning and community risk assessment."

Additionally, Mark Masters, formerly of the Oklahoma-Arkansas Interagency Fire Coordination Center, Bureau of Indian Affairs in Hot Springs AR, said, "The OK-FIRE site is very important to predicting high fire danger staffing levels. The site-specific data are used to pre-position suppression resources."

Beyond Oklahoma

Since OK-FIRE is now a thriving program in Oklahoma, it can serve as a prototype for similar state or national weather-based wildland fire management systems. With the following information, technical developers and fire professionals in other states and regions can begin to create their own wildland fire management system.

Fortunately for Oklahoma, developers were able to incorporate the Oklahoma Mesonet into the OK-FIRE system. While these networks are becoming more prevalent in other states and have great potential as operational fire management systems, they are more commonly used for agricultural applications.

For those states or regions without an automated weather station network, a forecast component could be developed for fire weather variables and surface smoke dispersion by using the methodologies in the Oklahoma Dispersion Model. Also, a forecast component could be included for 1-hour dead fuel moisture, since fuel moisture in these fine fuels is not that dependent on antecedent conditions. However, users would not be able to obtain information on 10-, 100-, and 1,000-hour fuels, as that information is reliant on initial fuel moisture conditions at the start of the forecast period using input from an automated weather station network.

If an automated weather station network does exist, a wildland fire management system could be created to emulate OK-FIRE. The network could provide recent and current fire weather, fire danger, and smoke dispersion conditions, the 10-, 100-, and 1,000-hour fuel moisture and KBDI could be calculated, and the NFDRS could be implemented to the area of concern. To create a model similar to the OKFD model, the model must be integrated with weekly satellite Normalized Difference Vegetation Index (NDVI) data to calculate visual and relative greenness and live fuel moisture, and to apportion live and dead fuel loads for the fuel model assigned each 1-km pixel of land. Compared to the forecast-only system mentioned above, this system development would require a high level of programming skill and an extensive amount of time and technical resources.

To display products on the designated Website, using a browser plug-in is one possibility, like the locally developed one used for OK-FIRE which allows for map animation, zooming, and overlays. Once all of the products and Website had been created, developers could then begin conducting user training workshops.

Management Implications

Located at http://okfire.mesonet.org, OK-FIRE provides fire professionals with the ability to:

- Access weather, fire danger, and smoke management products and multi-day forecasting capabilities at one location.
- Improve the planning and execution of prescribed burning.
- Better anticipate severe wildfire conditions, determine optimal staffing levels, track existing and forecast weather conditions during wildfires, and receive guidance for county burn ban decisions.
- Find out about upcoming OK-FIRE training workshops.

For those institutions or agencies that are unable to build their own wildland fire management system, the following resources are available on a nationwide scale:

- **Forest Service, Wildland Fire Assessment System (WFAS)**—Offers a variety of products for both current and forecast periods and is an example of a national operational system for fire danger estimation.
- **Mesoscale MM5 model**—Produces weather, fire danger, and smoke dispersion forecasts up to three days in the future for different geographical regions.
- **National Weather Service**—Provides current and forecasted fire weather.

Getting better every year

Now a funded program of the Oklahoma Mesonet, OK-FIRE continues to evolve, offering new features, products, and enhanced capabilities. For example, this past fall a recent modification expands the current capabilities of the fire danger model by allowing users to choose from 11 NFDRS fuel models for a specific Mesonet location. Developers also hope to create a cell-phone optimized version of OK-FIRE to be used in the field, ensuring greater access to the information that fire managers need at the time they need it, regardless of location.

User training will also continue for the foreseeable future. OK-FIRE workshops have proven very popular as they occur in a computer lab setting, which allows the users hands-on experience with the Website via sets of lab exercises dealing with various topics and sections of the Website. In addition, OK-FIRE developers hope to create online training modules for those individuals who may not be able to attend the training workshops.

Further Information: Publications and Web Resources

Fire Consortium for the Advanced Modeling of Meteorology and Smoke: http://airfire.org/fcamms

Forest Service, Wildland Fire Assessment System: http://www.wfas.net/

National Weather Service: http://www.nws.noaa.gov/

OK-FIRE: http://okfire.mesonet.org

Pennsylvania State University/National Center for Atmospheric Research, developer of the MM5 model: http://www.mmm.ucar.edu/mm5/

Scientist Profile

Having been at Oklahoma State University since 1991, J.D. Carlson provides research and extension support for programs associated with the Oklahoma Mesonet. In particular, his expertise includes boundary-layer meteorology, agricultural and fire meteorology, and atmospheric dispersion. J.D.'s major efforts over the past number of years have centered on developing OK-FIRE and in training wildland fire managers on the use of OK-FIRE with respect to both wildfire and prescribed fire. With a partial extension appointment, he also serves as the state extension specialist in agricultural and fire meteorology. Dr. Carlson received a BS in Physics from Michigan State University, an MS in Meteorology from the University of Wisconsin-Madison, and a PhD in Atmospheric Sciences from The Ohio State University. He is currently a fellow in the Royal Meteorological Society as well as a member of the American Meteorological Society and International Society of Wildland Fire.

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