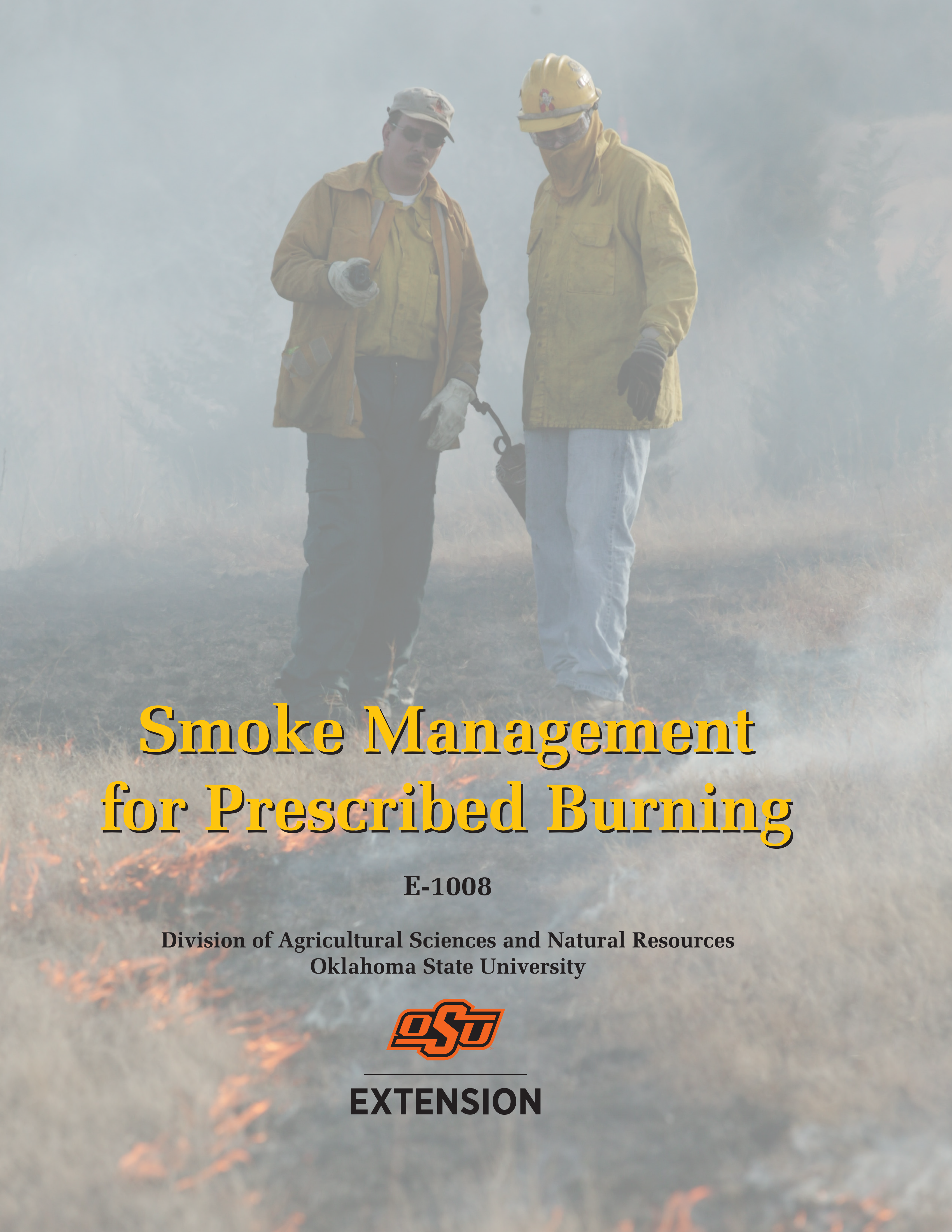

Smoke Management for Prescribed Burning

E-1008

Division of Agricultural Sciences and Natural Resources
Oklahoma State University

EXTENSION

Smoke Management for Prescribed Burning

John R. Weir
Extension Specialist for Fire Ecology

J. D. Carlson
Extension Specialist for Fire Meteorology

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Director of Oklahoma Cooperative Extension Service, Oklahoma State University, Stillwater, Oklahoma. This publication is printed and issued by Oklahoma State University as authorized by the Vice President for Agricultural Programs and has been prepared and distributed at a cost of $1.20 per copy. Revised February 2021.

Introduction

Smoke management should be an important consideration when planning all prescribed burns. Smoke can obstruct visibility, which in turn can affect the safety of the personnel conducting the fire, public safety on roadways and the recreational value of areas. Smoke also can impact public health, along with the public's reaction to prescribed burning in general. Nuisance smoke is smoke that causes problems and is defined as the amount of smoke in the air that interferes with a right or privilege common to members of the public, including the use or enjoyment of public or private resources. That is why it is important to manage smoke emissions—so there are no problems on current or future burns. The main goals of smoke management are to reduce emissions from a fire, improve the dispersion of smoke and make sure smoke plumes do not affect smoke-sensitive areas (e.g., communities, roads).

Smoke is a by-product of incomplete combustion caused by the inefficient mixing of oxygen and fuel. There are four stages of combustion, and the amount of fuel consumed as well as the amount of smoke produced is distinctive for each stage.

- **pre-ignition:** when fuel particles are initially heated, water vapor is expelled into the atmosphere.
- **flaming:** efficiency of combustion is relatively high and the least amount of emissions are produced in relation to the amount of fuel consumed.
- **smoldering:** efficiency of combustion is lower, thus resulting in greater particulate emissions. It has been documented that the amount of particulate emissions produced per amount of fuel consumed during this stage is more than double that of the flaming stage.

Smoke is a by-product of incomplete combustion caused by the inefficient mixing of oxygen and fuel. Ninety percent of smoke emissions from wildland fires are carbon dioxide and water vapor. (photo John Weir)

- **glowing stage:** characterized by minimal smoke because all of the volatile material in the fuel has been driven out and oxygen can now easily reach the fuel particles, making combustion more efficient.

Smoke is found in all stages of combustion, but it is greatest in the smoldering phase. Smoke is more prevalent during smoldering combustion of duff, decaying logs and organic soils than in grass, shrub and small diameter wood.

Smoke Emissions

Carbon dioxide is the largest single emission from wildland fire. Although it is not considered an air pollutant, carbon dioxide is an important greenhouse gas. Water vapor is the second largest emission from wildland fire. It is not considered an air pollutant, but it does contribute to the total smoke load and causes reduction in visibility. Smoke emissions from fires are 90% carbon dioxide and water vapor.

The remaining 10% of smoke emissions consist of other compounds such as carbon monoxide, hydrocarbons, nitrogen oxides and particulate matter (PM). Particulate matter consists of small airborne particles. In wildland fire smoke, 70% of these are less than 2.5 microns in diameter. These particles degrade air quality by reducing visibility, absorbing harmful gases and aggravating respiratory problems in susceptible individuals, along with collecting on surfaces, causing damage and reducing aesthetic appeal.

How to Minimize Smoke Problems

There are many methods that can be used to reduce the impact of smoke outside of the burn unit. Some of the methods are easy to accomplish, while others may require additional labor and can add expense to the burn. The simplest method to reduce smoke problems is

Smoke management should be an important consideration when planning all prescribed burns. Smoke can obstruct visibility, which can affect public safety on roadways. (photo John Weir)

to burn with wind directions that do not impact people, communities or roads. Secondly, burn smaller units; reduced fuel loads create less smoke. This may require land managers to conduct more burns which can increase cost and take more time, but if it is the only way smoke problems can be mitigated, then it is the best method. The following are additional methods that can be used to reduce smoke problems:

Burn when weather conditions are likely to produce the best dispersion:

- Burn when atmospheric conditions are best for rapid smoke dispersal; this is normally after the morning inversion layer has broken and before the evening inversion layer forms. An inversion is a stable layer of air in which temperature increases with height and smoke dispersion is poor.
- Choose wind directions that take smoke away from people, communities and roads.
- Burn when the atmosphere is neutral to unstable, which enhances plume rise and the horizontal and vertical dispersing of smoke.
- Burn at night ONLY if you have a favorable forecast, because nighttime temperature inversions will cause smoke to hold at ground level.
- Consider air pollution regulations and do not burn during pollution alerts, stagnant conditions or ozone alert days because smoke will then aggravate an already bad situation.
- Burn only if minimal parameter values are met for acceptable smoke dispersal; these include minimum surface and upper level wind speeds, desired wind direction, minimum mixing height, category day and dispersion index.
- Take into account down-drainage smoke flow, especially in complex terrain where downslope winds prevail at nighttime under light wind conditions.
- Burn only after evaluating smoke dispersion conditions with a dispersion model (such as in OK-FIRE, to be discussed later) and a smoke plume trajectory plot (see OSU Extension publication E-927, *Using Prescribed Fire in Oklahoma*).

Burn when fuel conditions are likely to produce the least amount of smoke:

- Burn with proper fuel moisture conditions. This can be accomplished by selecting the correct fuel moisture range for the fuel size class that needs to be removed to meet the burn objectives. For removal of fine fuels, burn when the relative humidity is low enough for these fuels to burn and larger fuels are too wet to ignite. Consult the OK-FIRE website for fuel moisture conditions in a specific area.
- Use test fires prior to burning to confirm fuel conditions and smoke behavior before igniting the entire unit. This is accomplished by igniting a small area inside the burn unit that can be easily contained and extinguished, then observing how well the smoke lifts and disperses. If conditions are

Conducting burns when atmospheric conditions are best for rapid smoke dispersal or when the atmosphere is neutral to unstable will aid with the smoke rising and dispersing (top photograph). The fire in the bottom photograph was conducted on a day when atmospheric conditions were not favorable for smoke dispersal. Notice how the smoke is trapped near the surface. (photos by John Weir)

Fuel type will make a difference in smoke emission. Hardwood leaf litter will typically produce more smoke than grass fuels. (photo by John Weir)

not favorable, extinguish the test burn and wait for better atmospheric conditions.

- Estimate the amount of smoke the fuels will produce. This is sometimes difficult to determine and comes with experience. An area that has not been burned in years will create greater amounts of smoke than frequently burned areas.
- Fuel type will make a difference in emission rates; fuels that have high moisture contents, high concentration of oils or large fuel particle size will have higher rates of smoke emissions.

Utilize suitable ignition techniques for smoke management:

- Consider burning using backfires to reduce the amount of smoke produced. Backfires consume higher amounts of fuel in the flaming rather than the smoldering stage of combustion, thus produce less smoke per unit of time.
- Use mass ignition techniques like ring firing and headfires to create greater amounts of heat which will create more lift for the smoke column. (see OSU Extension video VT-112, *Using Prescribed Fire in Oklahoma* for examples)
- Utilize mass ignition devices such as heli-torch, DAIDS or terra-torch to create high-intensity fires that can limit the duration of smoke impacts and increase convection.

Conduct post-burn mop-up to reduce nuisance smoke:

- Outline what actions will be taken after the burn to reduce residual smoke, like prompt mop-up, mop-up of certain fuels or complete mop-up of all smoking fuels.
- If residual smoke problems from logs, brush piles, snags or stumps may be a problem, take steps to keep them from burning. If they do ignite, extinguish them quickly.

Before the burn, outline what actions will be taken to reduce residual smoke. Measures such as prompt mop-up, monitoring the burn unit, and having personnel in place to suppress any fuels that begin to smolder are methods to reduce the impact of post-burn smoke. (photo by Stephen Winter)

- If post-burn smoke could be a problem, be sure to monitor the burn unit and have personnel in place to suppress any fuels that begin to smolder.

Reduce the amount of fuels to reduce smoke emissions:

- Use periodic maintenance-type prescribed burns that follow historic natural fire return intervals.
- Consolidate non-merchandisable material in commercial forestry areas, have timber sales of multiple products, use chemical or mechanical treatments and allow firewood cutting.
- Utilize single or multi-species grazing on rangelands to reduce fine fuels or use haying practices.
- Exercise care when using certain mechanical treatments because they can increase the amount of fuel and volatility of fuels within a burn unit.

Reduce the impact of smoke on people:

- Notify all people that could possibly be affected downwind, such as nearby residents, adjacent landowners, fire departments and local fire control offices. This is a common courtesy and common sense.
- Inform smoke-sensitive persons how to avoid smoke exposure.
- Re-locate or provide clean-air facilities for sensitive persons until the risk is over.
- Mop-up along roads as soon as possible and pay special attention when roads are in areas where smoke can travel downslope or down drainage.
- Use appropriate signage to inform the public about areas where smoke will impact them, such as highways, secondary roads, trails and campgrounds.
- Initiate public education or public relations prior to conducting burns.
- Notify local fire departments before burning.
- Be prepared to monitor roads for smoke. If smoke becomes an issue, have a plan in place

Use appropriate signage to inform the public about areas where smoke will impact them. This will reduce prescribed fire smoke-related problems and conflicts. (photo by Adam Gourley)

to control traffic until smoke is no longer a problem.

It is up to the fireboss to manage the smoke on each fire. The incorporation of one or more of these smoke-impact-reduction methods can reduce both current and future problems on most prescribed fires. Remember—even when the smoke leaves the burn unit, it is still smoke and everything possible should be done to reduce the impacts on people outside of the burn unit.

OK-FIRE: Weather-based Tools for Smoke Management

Wildland fire managers in Oklahoma are fortunate to have a state-of-the-art automated weather station network, the Oklahoma Mesonet. The network is jointly operated by the University of Oklahoma and Oklahoma State University. Operational since 1994, the Oklahoma Mesonet currently consists of 120 weather towers (10 meters tall) with an average station spacing of 19 miles (Figure 1). Weather information is relayed every 5 minutes and is available on Mesonet websites within about 7 minutes of being sent. Thus, fire managers can access current weather conditions critical to smoke management with updates every 5 minutes.

Fire managers can access this Mesonet weather information plus a wealth of other weather-based fire management products on OK-FIRE, a weather-based wildland fire decision support system: mesonet.org/index.php/okfire

OK-FIRE, a program of Oklahoma State University in conjunction with the Oklahoma Mesonet, was developed as a result of a 3-year federal grant from the Joint Fire Science Program. OK-FIRE products focus on three areas: fire weather, fire danger, and smoke dispersion. These products utilize the Oklahoma Mesonet for current and recent conditions and the North American Model (NAM) of the National Weather

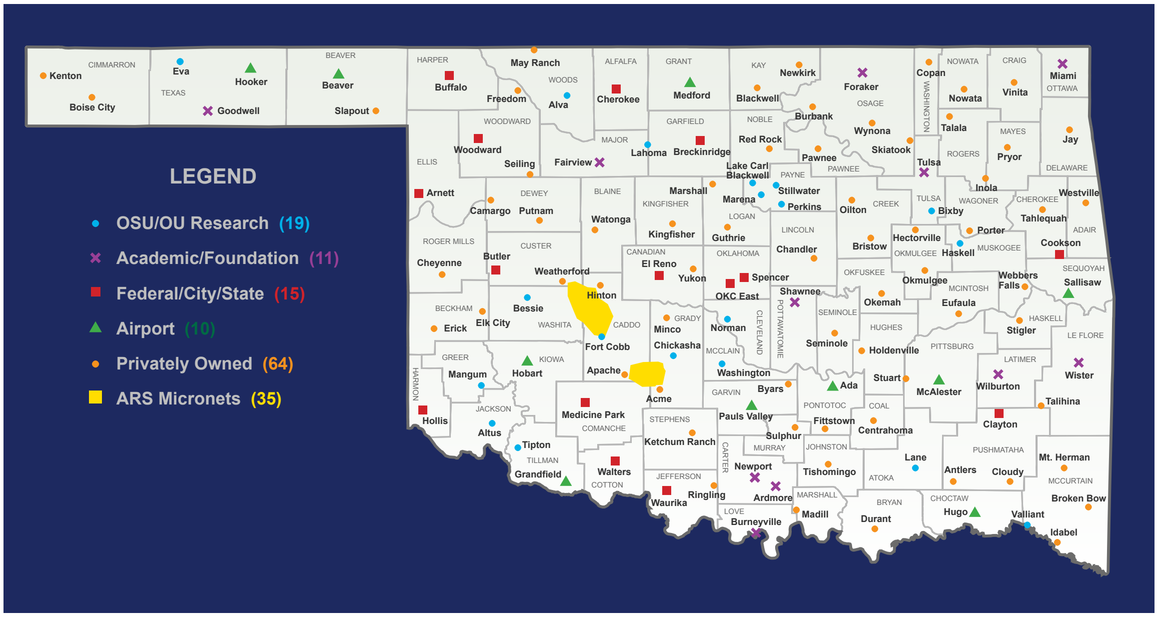

Figure 1. Location of Oklahoma Mesonet sites.

Service for forecast conditions. The NAM forecasts, which predict 84 hours into the future, are incorporated by OK-FIRE every 6 hours, using the 00Z, 06Z, 12Z and 18Z operational runs of the model.

OK-FIRE products are available in the following formats: (1) maps, many of which can be animated; (2) site-specific charts; and (3) site-specific tables. These products can be viewed over the previous 30 days (previous 52 weeks for some long-term variables) through the latest 84-hour forecast period.

Oklahoma Dispersion Model

The Oklahoma Dispersion Model was developed to assess surface dispersion conditions up to several miles downwind. It breaks the atmosphere into six dispersion categories:

1 = Very Poor (VP)
2 = Poor (P)
3 = Moderately Poor (MP)
4 = Moderately Good (MG)
5 = Good (G)
6 = Excellent (EX)

In the map products, dispersion category 1 is red, category 2 is orange, category 3 is beige, while categories 4 through 6 are in increasing shades of green (Figure 2).

The lower end of this scale (1 and 2) typically occurs with inversion conditions, which inhibit mixing and lead to poor dispersion. During such conditions, the smoke plume hangs together as it drifts downwind and anyone caught near the plume centerline could be smoked out. The upper end of this scale (5 and 6) typically occurs with unstable atmospheric conditions, when the dispersion is good, both in the vertical and horizontal directions. The Oklahoma Dispersion Model can be interpreted as follows — for a given distance downwind, smoke concentrations near the plume centerline will be least under the excellent (EX) category and highest under the very poor (VP) category. For further details, consult the OSU Extension publication BAE-1739, *Movement of Odors Off-Farm*.

Dispersion Products

A large number of dispersion products from the Oklahoma Dispersion Model can be found on the OK-FIRE website. They are available in map format for viewing conditions over the entire state, as well as in chart and table formats for individual Mesonet site locations. Current dispersion conditions can be found on the OK-FIRE home page in the weather data tables for the primary/secondary sites selected as well as in the "Current Station Conditions" section of the website. Current maps of dispersion and inversion conditions are located in the "Current Maps" section of the website.

Current, past and forecast dispersion maps are available in the "Past & Forecast Animated Maps" section of the OK-FIRE website. To view

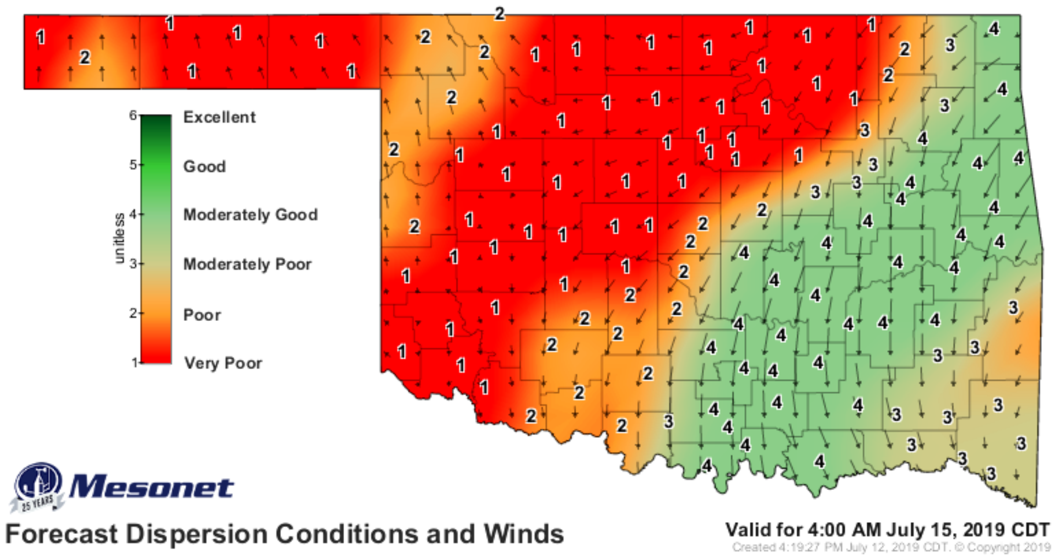

Figure 2. Example of a forecast dispersion map from the Oklahoma Dispersion Model.

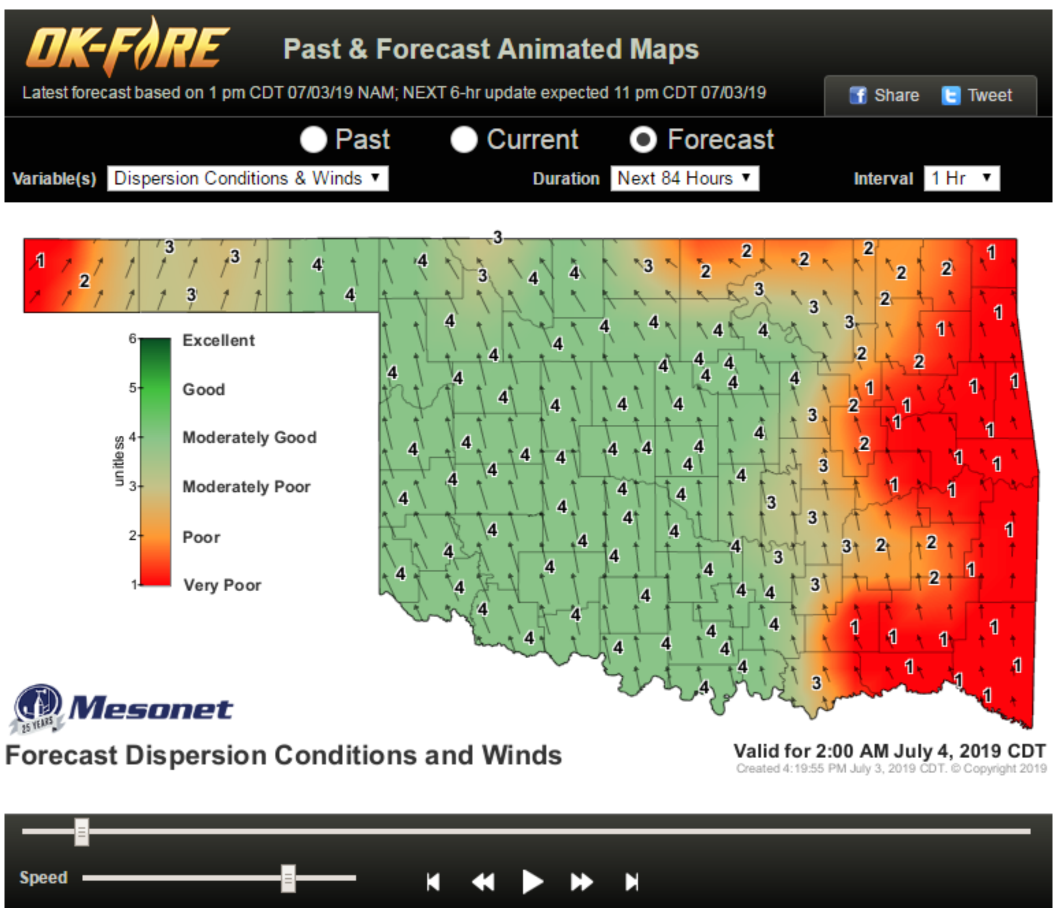

Figure 3. The dynamic map interface in the OK-FIRE website where past, current and forecast dispersion maps can be viewed.

current dispersion conditions, select "Dispersion Conditions & Winds" in the pull-down "Variable(s)" menu and then select "Current" as the time mode. Animations are possible for past time periods as well as through the 84-hour forecast. For either, select "Past" or "Forecast" as the time mode. Note that one can also select "Duration" and "Interval" for the animation. Then use the animation buttons at the bottom to advance through the time period that appears in the "Duration" field at the top. The middle button at the bottom is a play/pause toggle; the first and last buttons take one to the first and last frames, respectfully, of the animation; and the second and fourth buttons allow one to manually advance backward or forward in time. Figure 3 shows this dynamic map interface section of the website. The animation has been stopped at 2:00 a.m. July 4, 2019, showing very poor to poor dispersion conditions across eastern Oklahoma and the extreme western panhandle, with moderately good conditions across the rest of the state. Wind direction arrows show the direction a smoke plume would move, with the exception that under light wind conditions in the inversion areas (oranges and reds), the smoke plume would flow downhill to lower terrain due to cold air drainage.

In addition to maps, one can get past and forecast charts and tables at any Mesonet site location. For site-specific smoke dispersion applications, these product formats are likely to be more beneficial than maps as they provide a time series at one location of either past or forecast dispersion conditions, the latter being useful for planning purposes.

To access dispersion charts and tables, go to the "Past & Forecast Charts/Tables" section (Figure 4) of the OK-FIRE website. Select the Mesonet site of interest, then "Dispersion and Wind Conditions" in the "Variable(s)" pull-down menu. For the "Display Mode," select either "Charts" or "Tables;" for the "Time Mode," select either "Past" or "Forecast." As with the animated maps, note that "Duration" and "Interval" also can be selected for either charts or tables. Finally, click "Get Data."

With respect to charts, Figure 5 is an example of a forecast dispersion and wind chart

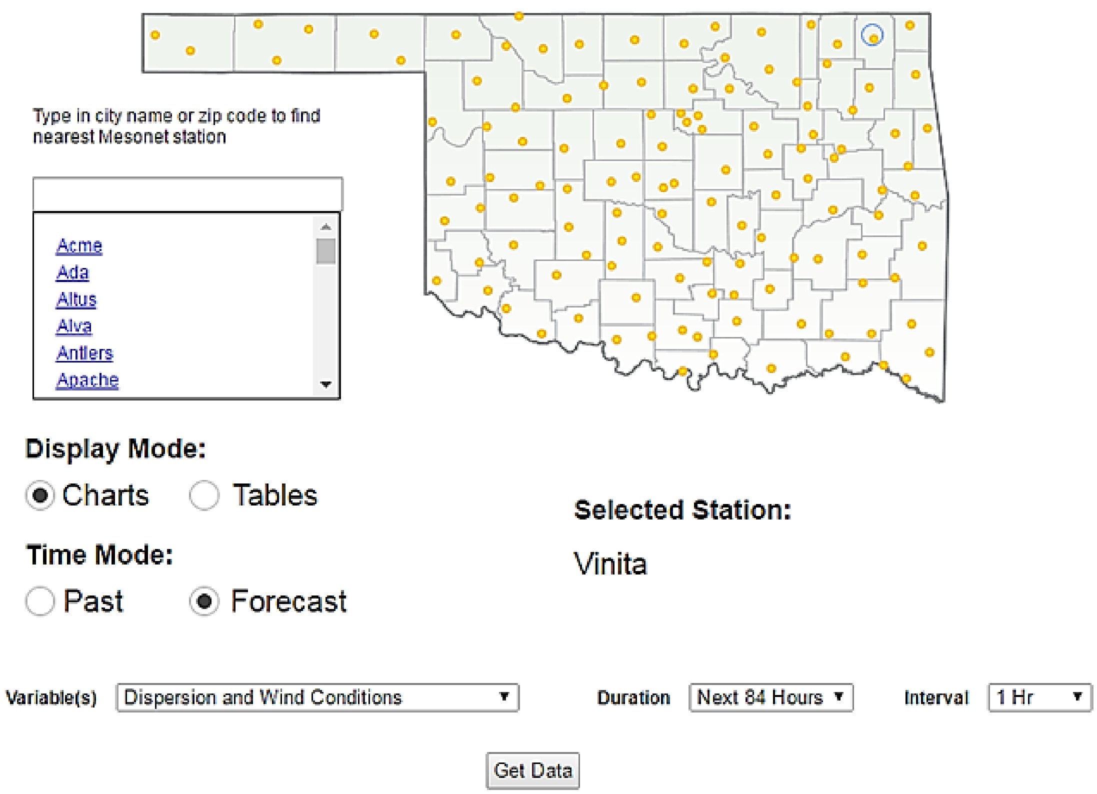

Figure 4. The interface for charts and tables in the OK-FIRE website where past and forecast charts or tables can be viewed.

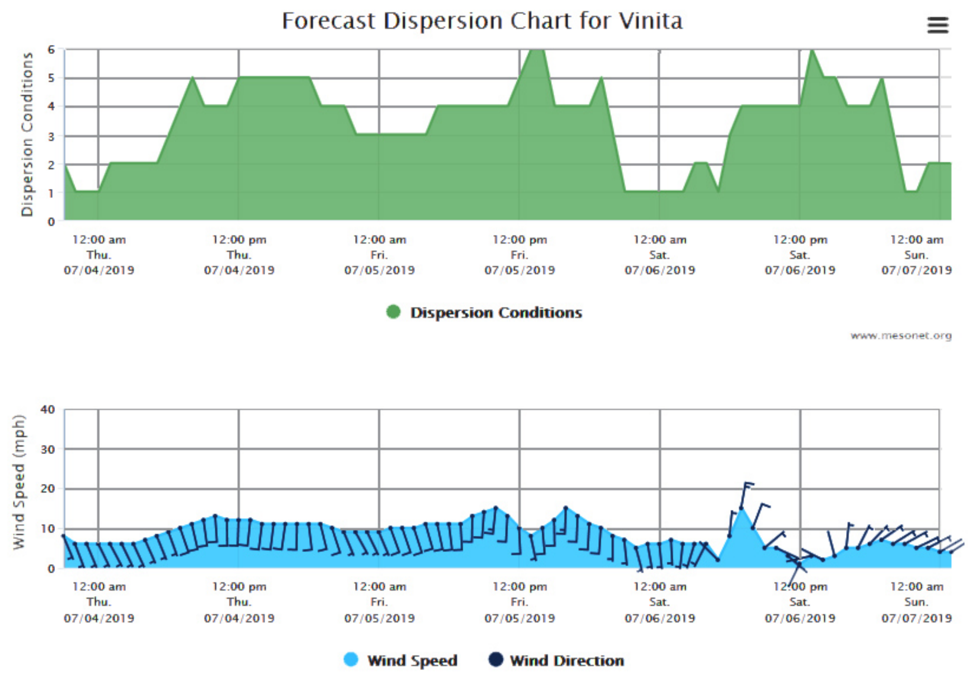

Figure 5. Example of a forecast dispersion and wind chart for Vinita. Predicted dispersion conditions (green) are shown in the top graph, and wind speeds (blue) and directions (staff/barb symbols) in the bottom graph.

Forecast Dispersion and Wind Conditions Table for Vinita

DATE / TIME	DISPERSION	WDIR	WSPD (mph)
Thu Jul 04, 2019 5:00 am CDT	P	SSE	8
Thu Jul 04, 2019 6:00 am CDT	MP	SSE	9
Thu Jul 04, 2019 7:00 am CDT	MG	SSE	10
Thu Jul 04, 2019 8:00 am CDT	G	SSE	11
Thu Jul 04, 2019 9:00 am CDT	MG	S	12
Thu Jul 04, 2019 10:00 am CDT	MG	S	13
Thu Jul 04, 2019 11:00 am CDT	MG	S	12
Thu Jul 04, 2019 12:00 pm CDT	G	S	12
Thu Jul 04, 2019 1:00 pm CDT	G	S	12
Thu Jul 04, 2019 2:00 pm CDT	G	S	11
Thu Jul 04, 2019 3:00 pm CDT	G	S	11
Thu Jul 04, 2019 4:00 pm CDT	G	S	11
Thu Jul 04, 2019 5:00 pm CDT	G	S	11
Thu Jul 04, 2019 6:00 pm CDT	G	S	11
Thu Jul 04, 2019 7:00 pm CDT	MG	SSE	11

Figure 6. Example of a forecast dispersion table for Vinita. Dispersion conditions, wind direction and wind speed are shown for each hour of the 84-hour forecast.

for Vinita through the 84-hour forecast period. The top graph shows the predicted dispersion conditions (vertical axis) from 1 (VP) to 6 (EX) through the forecast time period (horizontal axis), while the bottom graph shows the corresponding forecast wind speed and wind direction (staff/barb symbols). Winds blow in a direction parallel to the staff beginning at the barbed end. During the daytime on Thursday, Friday and Saturday, the dispersion conditions are forecast to be 4 (MG) or better. During the overnight hours on Thursday, Saturday and Sunday mornings, dispersion drops to 2 (P) or 1 (VP) due to very light wind speeds and (likely) temperature inversions. Smoke plumes during these conditions will drain gravitationally to lower elevations. However, during the overnight hours on Friday morning, dispersion is better with values of 3 (MP) or 4 (MG), due to slightly stronger wind speeds. Smoke plumes will likely move downwind to the north.

With respect to tables, Figure 6 shows a portion of the forecast dispersion table for Vinita from 5:00 a.m. through 7:00 p.m. on July 4, 2019. Note that the dispersion conditions are listed in the second column, the wind direction in the third column and the wind speed in the fourth. Good (G) dispersion is predicted from noon through 6:00 p.m., which would be a very suitable period for any activity that would emit smoke. The smoke plume would move toward the north with the predicted south winds. If no sensitive areas were located to the north of the smoke source, the time period for smoke emission could be extended to 7:00 a.m. through 7:00 p.m. since MG or better dispersion conditions are predicted through this period.

Fuel Moisture Products

As mentioned earlier, fuel moisture affects smoke production—generally, the more water a given fuel possesses, the more smoke will be given off. With high fuel moisture, most of the energy in the flaming phase will go into vaporizing water rather than burning dry matter, leaving more dry matter to burn in the smoldering phase. Of course, if fuel moisture is too high, the fuel won't burn; if fuel moisture is too low, dangerous and intense fire behavior can result.

Fuel moisture is therefore an important topic both for fire behavior and smoke management. In particular, dead fuel moisture (DFM) is important as it is the dead fuels which are most prominent during the prescribed burn and wildfire seasons in Oklahoma. For purposes of fire modeling, dead fuels are often broken into four categories: 1-hour fuels (less than 1/4-inch in diameter), 10-hour fuels (1/4-inch to 1-inch diameter), 100-hour fuels (1-inch to 3-inch diameter), and 1,000-hour fuels (3-inch to 8-inch diameter). As a general rule, with respect to fire behavior and safety issues, the preferred range of 1-hour DFM should be between 7% and 20% and 10-hour DFM between 6% and 15%. Higher fuel moisture values may result in low ignition and very little fire spread, while lower values may result in extreme fire behavior. Consult the OSU Extension fact sheet NREM-2878, *Fire Prescriptions for Restoration and Maintenance of Native Plant Communities* for more details.

OK-FIRE offers a wealth of fuel moisture products for the previous 30 days (previous 52 weeks for 100-hour and 1,000-hour fuels) through the latest 84-hour forecast period. As with other products, they are available in map, chart and table format (Figure 7). Current fuel moisture conditions can be found on the home page and in the "Current Station Conditions" and "Current Map" sections of the website. Past and forecast conditions can be found in the "Past and Forecast Animated Maps" and "Past and Forecast Charts/Tables" sections of the website.

Fire Prescription Planner

The "Fire Prescription Planner" on OK-FIRE allows the fire manager to specify lower and/ or upper limits for various variables pertaining to weather, dispersion conditions, dead fuel moisture and fire danger. After the prescribed values are entered, the user either utilizes the default Mesonet site from the home page or selects a different Mesonet site. Then, using forecast output from the latest 84-hour NAM model run, a table is produced for each hour of the forecast period showing which hours the prescription is met (for each prescribed variable and for all of them combined). Times when the criteria are met are shaded green, and those hours when they are not met are shaded red. This product is accessible from the left menu on the home page.

As an example, a fire manager near Vinita is considering a prescribed burn during the next three days and wishes to see when conditions might be suitable. The burn prescription calls for relative humidity between 40% and 80% and wind speeds between 5 mph and 15 mph.

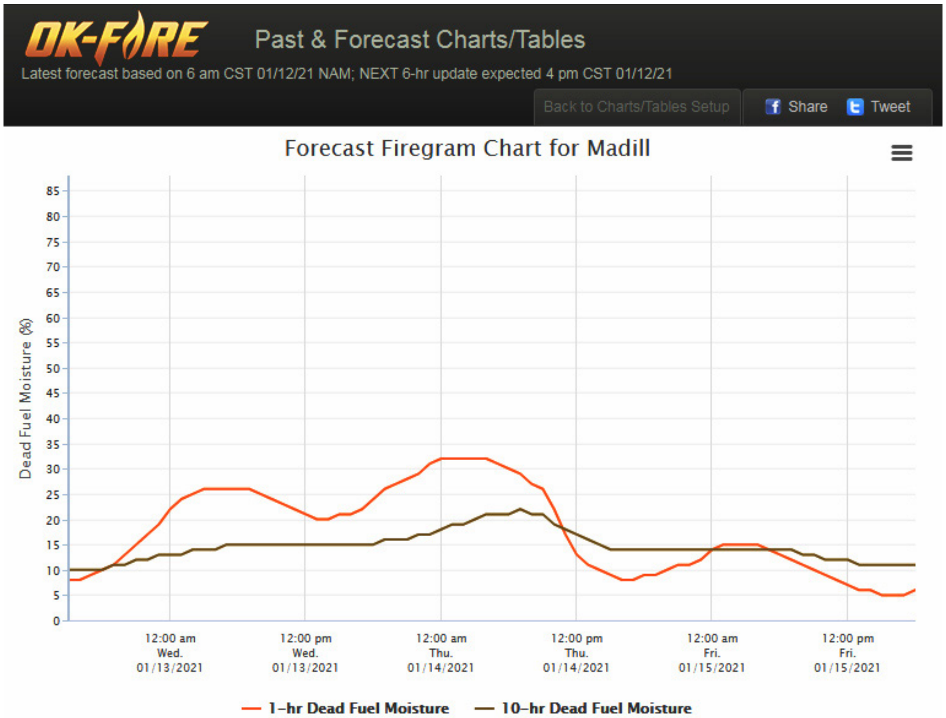

Figure 7. Forecast chart of 1-hr and 10-hr dead fuel moisture for Madill from OK-FIRE.

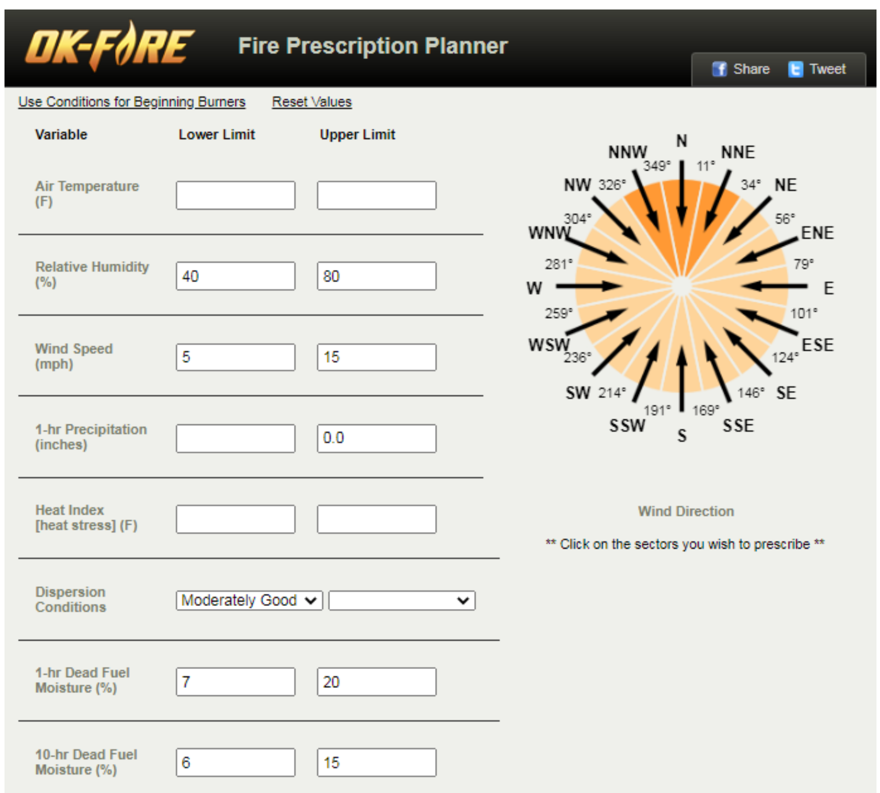

Figure 8. Initial table in the Fire Prescription Planner where prescription values are entered by the fire manager.

In addition, winds out of the northerly sectors (NNW, N or NNE) are desired. With respect to smoke management, the burn manager puts a lower limit on dispersion conditions of "Moderately Good." An upper limit of 0 for 1-hour precipitation also is entered. Finally, the dead fuel moisture for the burn is prescribed between 7% and 20% for 1-hour fuels and between 6% and 15% for 10-hour fuels. The first step in the Fire Prescription Planner involves the entry of this information for the prescribed elements. Note that not all data fields need be entered (Figure 8).

After the selection of the Mesonet site Vinita, a table is created showing which hours of the 84-hour forecast period meet or do not meet the prescription criteria. The resulting table for Vinita indicates a suitable period for such a burn between 8:00 a.m. and 1:00 p.m. the next day (Figure 9). Note the first column after the date/time column is entitled "Criteria Met?" and for these hours, those cells are shaded dark green, indicating all prescribed variable criteria are met during these hours. Also, wind directions are expected to be steady during this period (out of the NNW to N), which is important during prescribed burns.

Smoke Management Products from the National Weather Service

In addition to the Oklahoma Dispersion Model, which is designed to model surface dispersion up to several miles downwind, another system can be used for guidance in smoke management that deals with the ability of the atmosphere to mix and transport smoke for

OK-FIRE Fire Prescription Planner

Latest forecast based on 1 pm CDT 07/23/18 NAM; NEXT 6-hr update expected 11 pm CDT 07/23/18

Fire Prescription Table for Vinita Print Table

Disclaimer: *This forecast table, as with other OK-FIRE products, is based solely 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 forecast.*

Change Prescription or Site

DATE / TIME	Criteria Met?	TAIR	RELH	WDIR	WSPD	1hr PRECIP	DISPERSION	1hr DFM	10hr DFM
Mon 7/23/18 10 pm CDT	No	74°F	81%	NNE	6 mph	0.00 in.	1 (VP)	11%	9%
Mon 7/23/18 11 pm CDT	No	72°F	84%	NNE	6 mph	0.00 in.	1 (VP)	13%	11%
Tue 7/24/18 12 am CDT	No	71°F	87%	NNE	5 mph	0.00 in.	1 (VP)	15%	12%
Tue 7/24/18 1 am CDT	No	70°F	90%	NNE	5 mph	0.00 in.	1 (VP)	16%	14%
Tue 7/24/18 2 am CDT	No	69°F	89%	N	4 mph	0.00 in.	1 (VP)	18%	14%
Tue 7/24/18 3 am CDT	No	69°F	89%	N	4 mph	0.00 in.	1 (VP)	19%	15%
Tue 7/24/18 4 am CDT	No	69°F	89%	NNW	4 mph	0.00 in.	1 (VP)	19%	15%
Tue 7/24/18 5 am CDT	No	69°F	89%	NNW	4 mph	0.00 in.	1 (VP)	19%	15%
Tue 7/24/18 6 am CDT	No	69°F	89%	NNW	4 mph	0.00 in.	1 (VP)	19%	16%
Tue 7/24/18 7 am CDT	No	69°F	90%	NNW	4 mph	0.00 in.	2 (P)	19%	16%
Tue 7/24/18 8 am CDT	Yes	74°F	79%	NNW	5 mph	0.00 in.	4 (MG)	16%	16%
Tue 7/24/18 9 am CDT	Yes	79°F	69%	NNW	6 mph	0.00 in.	4 (MG)	14%	16%
Tue 7/24/18 10 am CDT	Yes	84°F	59%	N	7 mph	0.00 in.	5 (G)	11%	15%
Tue 7/24/18 11 am CDT	Yes	87°F	55%	N	8 mph	0.00 in.	6 (EX)	9%	14%
Tue 7/24/18 12 pm CDT	Yes	89°F	50%	N	9 mph	0.00 in.	6 (EX)	8%	13%
Tue 7/24/18 1 pm CDT	Yes	91°F	46%	N	10 mph	0.00 in.	6 (EX)	7%	11%
Tue 7/24/18 2 pm CDT	No	91°F	44%	N	10 mph	0.00 in.	6 (EX)	6%	10%
Tue 7/24/18 3 pm CDT	No	92°F	43%	N	10 mph	0.00 in.	6 (EX)	6%	9%
Tue 7/24/18 4 pm CDT	No	92°F	42%	N	10 mph	0.00 in.	6 (EX)	6%	9%

Figure 9. Resulting forecast table for Vinita in the Fire Prescription Planner.

large distances throughout the boundary layer (the mixed layer), which can extend upwards of 5,000 feet above the surface. The "Mixing Height" is the depth of the layer above the ground throughout which smoke can be dispersed. "Transport Wind" is the average wind speed through the depth of that layer. Multiplying these two variables gives "Ventilation Rate" (VR), which is an estimate of the ability of the atmosphere to ventilate the area. A variable called "Category Day," which is a function of VR and ranges from 1 to 5, has been developed as a smoke management index to provide guidance as to when and when not to burn. A Category Day value of 1 represents the worst boundary-layer dispersion conditions during which no burning should occur, while a Category Day value of 5 represents the best boundary-layer dispersion conditions. This system is more fully described in the OSU Extension publication E-927, *Using Prescribed Fire in Oklahoma*.

Category Day forecasts can be obtained from local National Weather Service (NWS) offices serving Oklahoma (Amarillo, Norman, Tulsa and Shreveport). Links to their fire weather web pages can be found in the "Additional Resources" section of the OK-FIRE website under "NWS Fire Weather Forecasts." The fire manager can click on the NWS office serving the area of concern and view predictions of Category Day through the 84-hour period. For more details, consult the OSU Extension publication E-927, *Using Prescribed Fire in Oklahoma.*

It is important to consult both the Oklahoma Dispersion Model, which relates to surface dispersion conditions, and the Category Day system, which relates to the capacity of the boundary layer to disperse the smoke. Under some circumstances the Oklahoma Dispersion Model could show good to excellent conditions at the surface, but the mixing height and/or transport wind could be so low that the smoke is trapped in a relatively small vertical layer above the surface (refer to earlier photo of entrapped smoke in the boundary layer).

References

Bidwell, T.G., J.R. Weir, J.D. Carlson, R.E. Masters and D.M. Engle, 2018. *Fire Prescriptions for Restoration and Maintenance of Native Plant Communities.* OSU Extension fact sheet NREM-2878, Oklahoma State University, 8 pp.

Bidwell, T.G., J.R. Weir, J.D. Carlson, R.E. Masters, S.D. Fuhlendorf, J. Waymire and S. Conrady, 2021. *Using Prescribed Fire in Oklahoma.* Circular E-927. OSU Extension, Oklahoma State University, 19 pp.

Carlson, J.D. and D.W. Hamilton, 2019. *Movement of Odors Off-Farm*, OSU Extension fact sheet BAE-1739, Oklahoma State University, 8 pp.

Hardy, C.C., R. D. Ottmar, J.L. Peterson, J. E. Core and P. Seamon, ed, 2001. *Smoke Management Guide for Prescribed and Wildland Fire* (2001 Edition). National Wildfire Coordinating Group, PMS 420-2, NFES 1279, 236 pp.

Using Prescribed Fire in Oklahoma VT-112, 2007. DVD video. OSU Extension, Oklahoma State University.

Notes

EXTENSION