SMOKE MANAGEMENT
and
PRESCRIBED FIRE

Questions You Should Be Able to Answer by the End of this Module

- **What are the two major adverse impacts of smoke?**

- **What is an inversion layer and what happens to smoke caught within it?**

- **Which of the six dispersion categories from the Oklahoma Dispersion Model are good for prescribed burning?**

- **How can the Fire Prescription Planner be used for prescribed burning?**

Smoke

Wildland Fire Emissions
(Health Impacts)

- **Carbon Dioxide (CO2) and Water Vapor**

- **Carbon Monoxide (CO)**

- **Hydrocarbons (HC)**

- **Nitrogen Oxides (NOx)**

- **Particulate Matter**
    - **< PM2.5 (70%)**
    - **PM2.5-10 (20%)**
    - **> PM10 (10%)**

**Wildland Fire Emissions
(Visibility Impacts)**

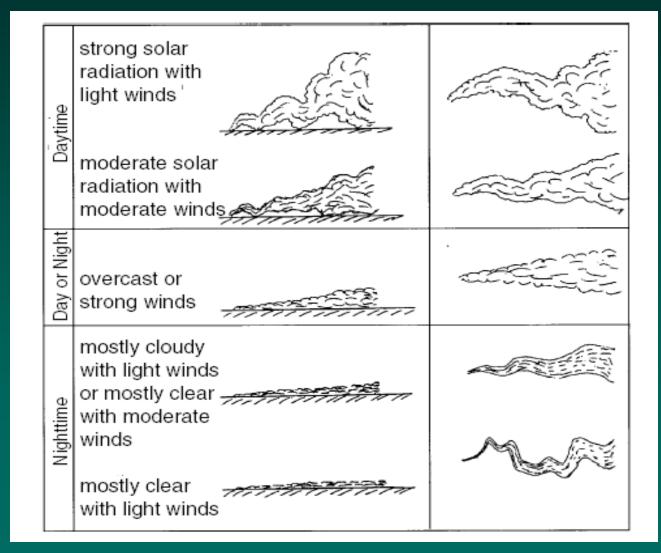# Atmospheric Dispersion

Atmospheric Dispersion =

the ability of the atmosphere to horizontally and vertically disperse and dilute embedded gases and/or particulate matter

TYPES OF ATMOSPHERIC DISPERSION

Weather Factors	Side View (vertical dispersion)	Top View (horizontal dispersion)	
Daytime — strong solar radiation with light winds			**UNSTABLE ATMOSPHERE**
Daytime — moderate solar radiation with moderate winds			
Day or Night — overcast or strong winds			**NEUTRAL ATMOSPHERE**
Nighttime — mostly cloudy with light winds or mostly clear with moderate winds			**STABLE ATMOSPHERE**
Nighttime — mostly clear with light winds			

Unstable Atmosphere – *Good* Dispersion

Figure 3
A closer view of the behaviour of the plume in convective conditions. Note the grounding of the plume indicated by the arrow.
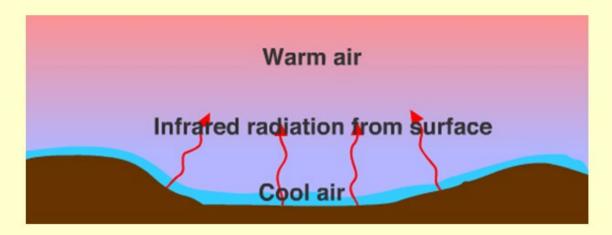
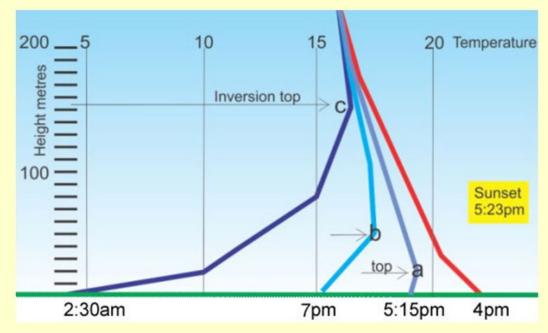# Neutral Atmosphere – *Moderate* Dispersion

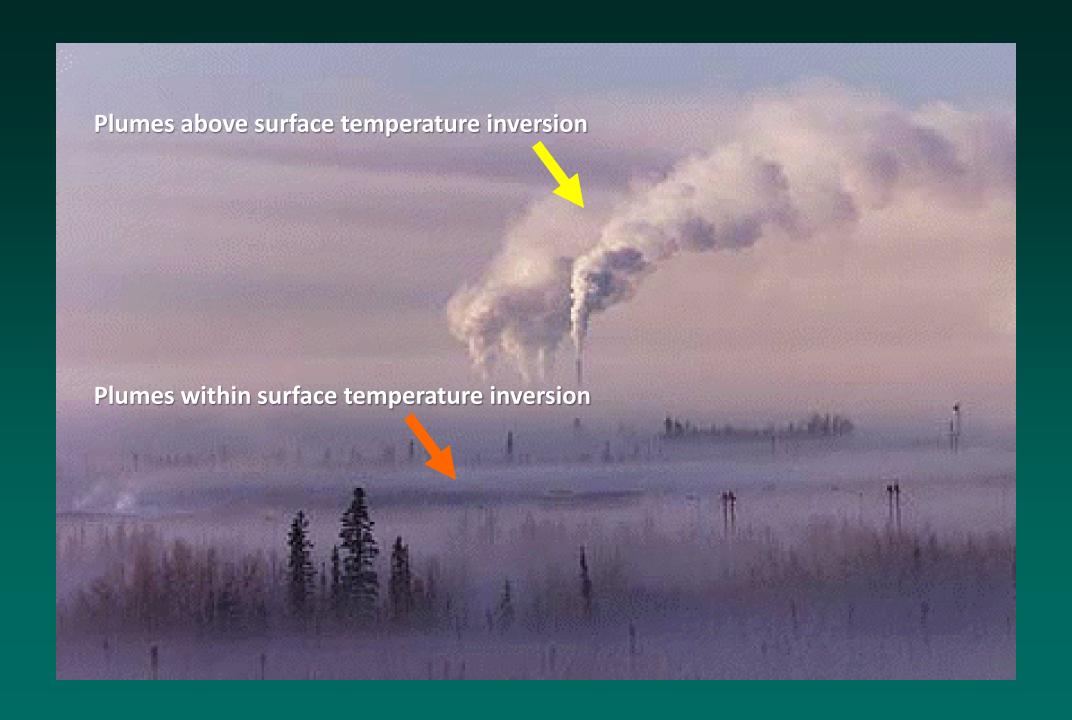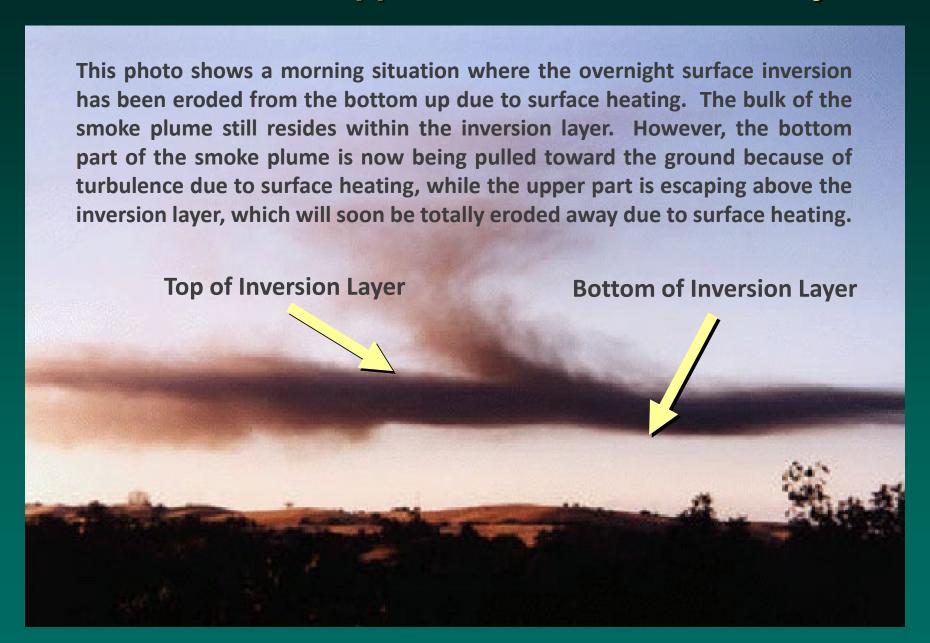# Stable Atmosphere – *Poor* Dispersion

Surface Radiation Inversion

Plumes above surface temperature inversion

Plumes within surface temperature inversion

Smoke Plume Trapped within an Inversion Layer

This photo shows a morning situation where the overnight surface inversion has been eroded from the bottom up due to surface heating. The bulk of the smoke plume still resides within the inversion layer. However, the bottom part of the smoke plume is now being pulled toward the ground because of turbulence due to surface heating, while the upper part is escaping above the inversion layer, which will soon be totally eroded away due to surface heating.
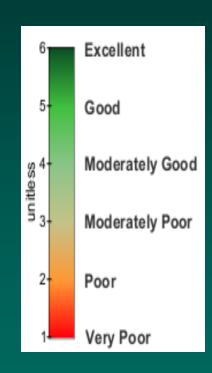
Top of Inversion Layer

Bottom of Inversion Layer

The Oklahoma Dispersion Model

(What are the relative downwind smoke levels near the surface where people live and drive ?)

Six Dispersion Categories

- **Excellent =**   **6.0 ("EX"; dark green)**
- **Good =**   **5.0 ("G"; green)**
- **Moderately Good =**   **4.0 ("MG"'; light green)**
- **Moderately Poor =**   **3.0 ("MP"; beige)**
- **Poor =**   **2.0 ("P"; orange)**
- **Very Poor =**   **1.0 ("VP"; red)**

TYPES OF ATMOSPHERIC DISPERSION

Excellent (EX=6)

Good (G=5)

Moderately Good (MG=4)

Moderately Poor (MP=3)

Poor (P=2)

Very Poor (VP=1)

Dispersion Conditions for Smoke

- **EX (6), G (5), MG (4)** — **Good conditions for prescribed burns**
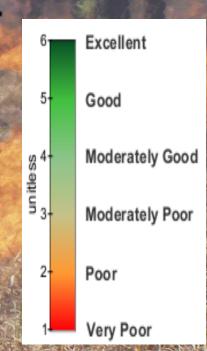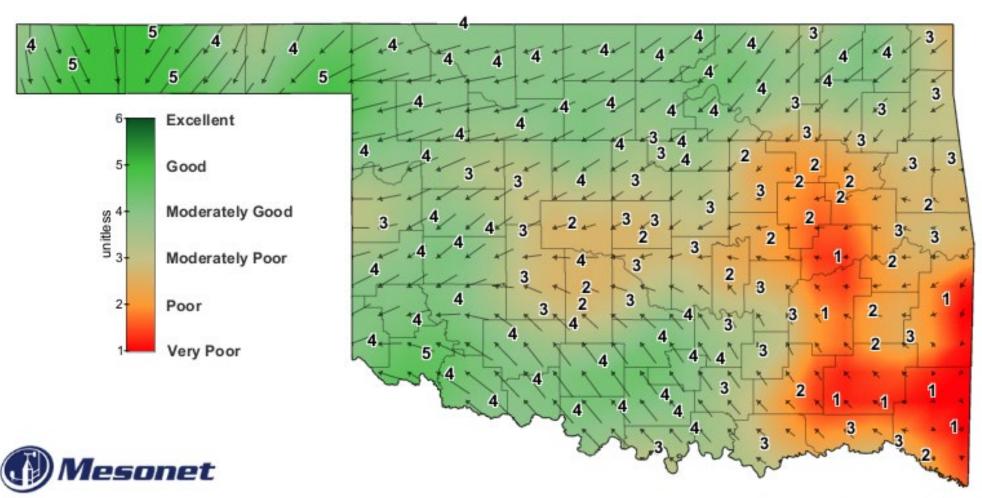
- **MP (3)** — **Acceptable if no sensitive areas downwind**
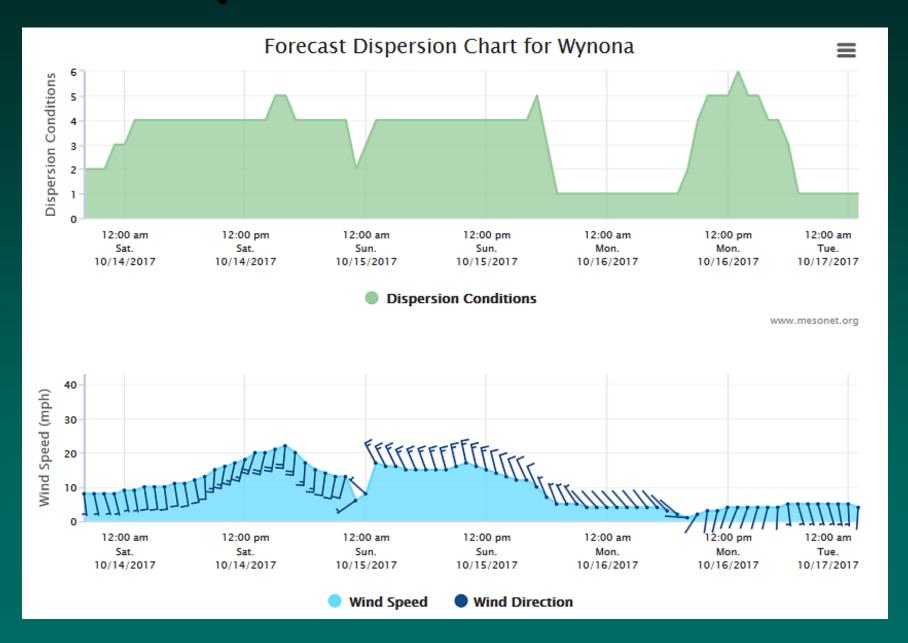
- **P (2), VP(1)** — **Avoid these times**

unitless	
6	Excellent
5	Good
4	Moderately Good
3	Moderately Poor
2	Poor
1	Very Poor

Dispersion and Wind Charts

Prescribed Burning

Relative Humidity
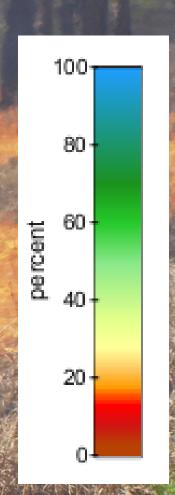
- **> 85%** Fuels may be too moist for fire; heavy smoke possible

- **35-85%** Normal range for prescribed burning

- **20-35%** Containment difficult; quick ignition; spot fires increase

- **< 20%** Extreme fire behavior; spot fires frequent

Wind Speed
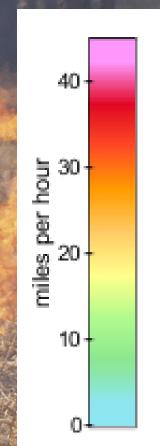
- **< 5 mph**   **Generally unsuitable for prescribed burning; variable direction**

- **5-15 mph**   **Normal range for prescribed burning**

- **15-20 mph**   **Threshold range**

- **> 20 mph**   **Increasingly problematic; spot fires increase; containment more difficult**

miles per hour

40
30
20
10
0

1 and 10-h Dead Fuel Moisture

1-hr fuels	10-hr fuels	Fire Behavior
> 20%	> 15%	Fuels too moist for fire spread; heavy smoke possible
7-20%	6-15%	Normal range for prescribed burning
5-7%	5-6%	Containment difficult; quick ignition; spot fires increase
< 5%	< 5%	Extreme fire behavior; spot fires frequent; burn with extreme caution

"Fire Prescription Planner"

Prescribed Burn Example

OK-FIRE
Fire Prescription Planner

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Reset Values

Variable	Lower Limit	Upper Limit
Air Temperature (F)	35	
Relative Humidity (%)	40	
Wind Speed (mph)	5	15
1-hr Precipitation (inches)		0.00
Heat Index [heat stress] (F)		90
Dispersion Conditions	Moderately Good ⌄	⌄
1-hr Dead Fuel Moisture (%)	8	20
10-hr Dead Fuel Moisture (%)	7	

Wind Direction

** Click on the sectors you wish to prescribe **

Burning Index (10*ft)		
Ignition Component (%)		
Spread Component (ft/min)		
Energy Release Component (BTU/ft2)		
KBDI (0-800)		

Stillwater Show: Next 84 Hours ☑ Show Prescribed Variables Only ☐ Save Settings as Default Get Data

DATE / TIME	Criteria Met?	TAIR	RELH	WDIR	WSPD	1hr PRECIP	HEAT INDEX	DISPERSION	1hr DFM	10hr DFM
Fri 10/29/21 1 pm CDT	No	56°F	58%	NNW	17 mph	0.00 in.	56°F	4 (MG)	9%	11%

DATE / TIME	Criteria Met?	TAIR	RELH	WDIR	WSPD	1hr PRECIP	HEAT INDEX	DISPERSION	1hr DFM	10hr DFM
Fri 10/29/21 2 pm CDT	No	56°F	58%	NNW	16 mph	0.00 in.	56°F	4 (MG)	9%	11%
Fri 10/29/21 3 pm CDT	Yes	57°F	59%	NNW	15 mph	0.00 in.	57°F	4 (MG)	9%	11%
Fri 10/29/21 4 pm CDT	Yes	57°F	59%	NNW	14 mph	0.00 in.	57°F	4 (MG)	10%	11%
Fri 10/29/21 5 pm CDT	Yes	56°F	61%	NNW	13 mph	0.00 in.	56°F	4 (MG)	10%	11%
Fri 10/29/21 6 pm CDT	Yes	55°F	62%	NNW	12 mph	0.00 in.	55°F	4 (MG)	10%	11%
Fri 10/29/21 7 pm CDT	Yes	55°F	64%	NNW	12 mph	0.00 in.	55°F	4 (MG)	11%	12%
Fri 10/29/21 8 pm CDT	Yes	54°F	65%	NNW	11 mph	0.00 in.	54°F	4 (MG)	11%	12%
Fri 10/29/21 9 pm CDT	Yes	54°F	67%	NNW	11 mph	0.00 in.	54°F	4 (MG)	11%	12%
Fri 10/29/21 10 pm CDT	Yes	54°F	68%	NNW	10 mph	0.00 in.	54°F	4 (MG)	12%	13%
Fri 10/29/21 11 pm CDT	Yes	52°F	72%	NNW	9 mph	0.00 in.	52°F	4 (MG)	12%	13%
Sat 10/30/21 12 am CDT	No	51°F	75%	NNW	8 mph	0.00 in.	51°F	2 (P)	13%	13%
Sat 10/30/21 1 am CDT	No	49°F	79%	NNW	7 mph	0.00 in.	49°F	1 (VP)	14%	14%
Sat 10/30/21 2 am CDT	No	48°F	81%	NNW	7 mph	0.00 in.	48°F	1 (VP)	15%	14%
Sat 10/30/21 3 am CDT	No	47°F	83%	NNW	7 mph	0.00 in.	47°F	1 (VP)	16%	15%
Sat 10/30/21 4 am CDT	No	46°F	85%	NW	7 mph	0.00 in.	46°F	1 (VP)	16%	15%
Sat 10/30/21 5 am CDT	No	45°F	86%	NW	7 mph	0.00 in.	45°F	1 (VP)	17%	15%
Sat 10/30/21 6 am CDT	No	44°F	87%	NW	6 mph	0.00 in.	44°F	1 (VP)	18%	16%
Sat 10/30/21 7 am CDT	No	43°F	88%	NW	6 mph	0.00 in.	43°F	1 (VP)	19%	16%
Sat 10/30/21 8 am CDT	No	45°F	82%	NNW	6 mph	0.00 in.	45°F	3 (MP)	18%	16%
Sat 10/30/21 9 am CDT	Yes	48°F	77%	NNW	6 mph	0.00 in.	48°F	4 (MG)	16%	15%

DATE / TIME	Criteria Met?	TAIR	RELH	WDIR	WSPD	1hr PRECIP	HEAT INDEX	DISPERSION	1hr DFM	10hr DFM
Sat 10/30/21 10 am CDT	Yes	50°F	71%	NNW	7 mph	0.00 in.	50°F	4 (MG)	14%	15%
Sat 10/30/21 11 am CDT	Yes	53°F	66%	NNW	7 mph	0.00 in.	53°F	4 (MG)	12%	14%
Sat 10/30/21 12 pm CDT	Yes	56°F	62%	NNW	7 mph	0.00 in.	56°F	4 (MG)	11%	13%
Sat 10/30/21 1 pm CDT	Yes	60°F	57%	NW	7 mph	0.00 in.	60°F	6 (EX)	10%	12%
Sat 10/30/21 2 pm CDT	Yes	61°F	54%	NW	7 mph	0.00 in.	61°F	4 (MG)	9%	12%
Sat 10/30/21 3 pm CDT	Yes	63°F	51%	NW	6 mph	0.00 in.	63°F	4 (MG)	8%	11%
Sat 10/30/21 4 pm CDT	Yes	64°F	48%	NW	6 mph	0.00 in.	64°F	4 (MG)	8%	11%
Sat 10/30/21 5 pm CDT	No	63°F	49%	NW	4 mph	0.00 in.	63°F	5 (G)	8%	10%

Wildfire Example

OK-FIRE

Fire Prescription Planner

Use Conditions for Beginning Burners   Reset Values

Variable	Lower Limit	Upper Limit
Air Temperature (F)		
Relative Humidity (%)		40
Wind Speed (mph)	15	
1-hr Precipitation (inches)		
Heat Index [heat stress] (F)		
Dispersion Conditions	⌄	⌄
1-hr Dead Fuel Moisture (%)		7
10-hr Dead Fuel Moisture (%)		
Burning Index (10*ft)	40	

Wind Direction

** Click on the sectors you wish to prescribe **

Wind compass directions:
N, NNE 11°, NE 34°, ENE 56°, 79°, E 101°, ESE 124°, SE 146°, SSE 169°, S 191°, SSW 214°, SW 236°, WSW 259°, W 281°, WNW 304°, NW 326°, NNW 349°

Fire Prescription Table for Woodward
(NFDRS Fuel Model T - Tallgrass with open evergreen brush)

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?	RELH	WSPD	1hr DFM	BI
Wed 10/27/21 10 pm CDT	No	45%	17 mph	8%	22
Wed 10/27/21 11 pm CDT	No	45%	18 mph	8%	22
Thu 10/28/21 12 am CDT	No	44%	18 mph	8%	22
Thu 10/28/21 1 am CDT	No	44%	19 mph	8%	23
Thu 10/28/21 2 am CDT	No	45%	18 mph	8%	22
Thu 10/28/21 3 am CDT	No	47%	18 mph	8%	21
Thu 10/28/21 4 am CDT	No	48%	17 mph	9%	20
Thu 10/28/21 5 am CDT	No	49%	18 mph	9%	20
Thu 10/28/21 6 am CDT	No	50%	18 mph	9%	20
Thu 10/28/21 7 am CDT	No	50%	18 mph	9%	20
Thu 10/28/21 8 am CDT	No	48%	21 mph	9%	22
Thu 10/28/21 9 am CDT	No	45%	23 mph	9%	25
Thu 10/28/21 10 am CDT	No	43%	25 mph	8%	29
Thu 10/28/21 11 am CDT	Yes	38%	27 mph	7%	45
Thu 10/28/21 12 pm CDT	Yes	34%	29 mph	7%	60
Thu 10/28/21 1 pm CDT	Yes	29%	31 mph	6%	71
Thu 10/28/21 2 pm CDT	Yes	26%	31 mph	6%	77
Thu 10/28/21 3 pm CDT	Yes	24%	30 mph	5%	81
Thu 10/28/21 4 pm CDT	Yes	21%	30 mph	5%	84
Thu 10/28/21 5 pm CDT	Yes	22%	28 mph	5%	82
DATE / TIME	Criteria Met?	RELH	WSPD	1hr DFM	BI
Thu 10/28/21 6 pm CDT	Yes	23%	26 mph	5%	77
Thu 10/28/21 7 pm CDT	Yes	24%	24 mph	5%	72
Thu 10/28/21 8 pm CDT	Yes	25%	23 mph	5%	68
Thu 10/28/21 9 pm CDT	Yes	26%	22 mph	5%	65
Thu 10/28/21 10 pm CDT	Yes	27%	21 mph	6%	61
Thu 10/28/21 11 pm CDT	Yes	29%	21 mph	6%	60
Fri 10/29/21 12 am CDT	Yes	30%	21 mph	6%	58
Fri 10/29/21 1 am CDT	Yes	31%	21 mph	6%	56
Fri 10/29/21 2 am CDT	Yes	34%	21 mph	6%	53
Fri 10/29/21 3 am CDT	Yes	38%	21 mph	7%	50

Burning Index (10*ft)	40	
Ignition Component (%)		
Spread Component (ft/min)		
Energy Release Component (BTU/ft2)		
KBDI (0-800)		

Woodward   Show: Next 84 Hours ⌄   ☐ **Show Prescribed Variables Only**   ☐ **Save Settings as Default**   Get Data
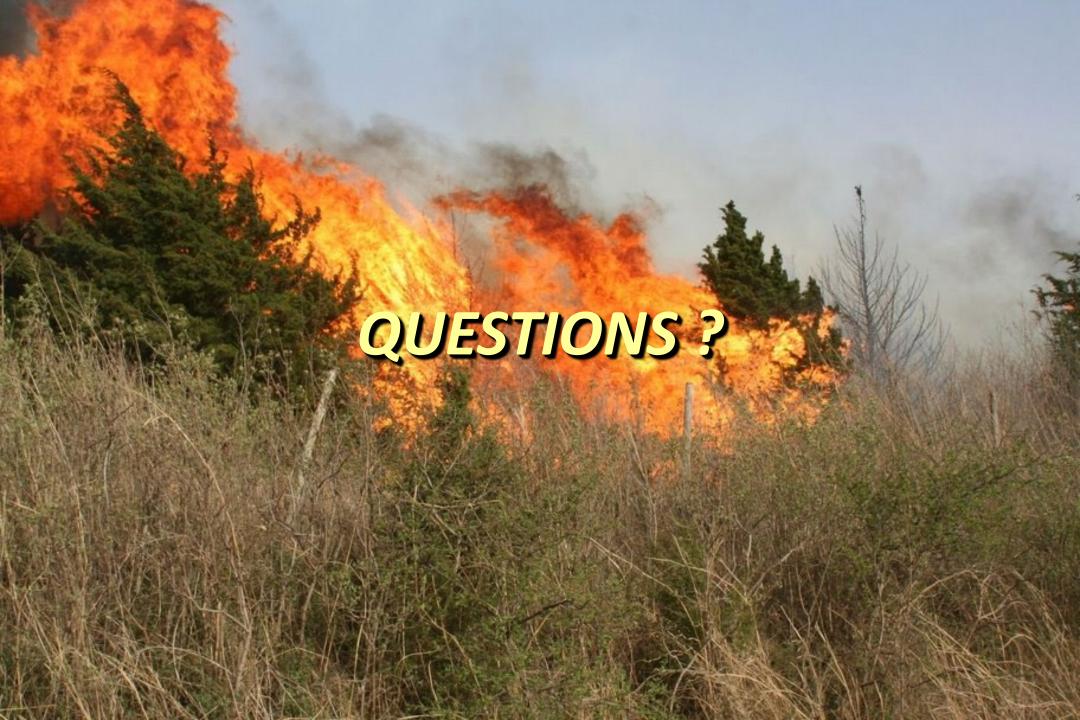
Fire Prescription Table for Woodward

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	BI	IC	SC	ERC	KBDI
Wed 10/27/21 10 pm CDT	No	54°F	45%	NW	17 mph	0.00 in.	4 (MG)	8%	13%	22	12%	22	3	515
Wed 10/27/21 11 pm CDT	No	53°F	45%	NW	18 mph	0.00 in.	4 (MG)	8%	13%	22	12%	23	3	515
Thu 10/28/21 12 am CDT	No	52°F	44%	NW	18 mph	0.00 in.	4 (MG)	8%	13%	22	12%	24	3	515
Thu 10/28/21 1 am CDT	No	52°F	44%	NW	19 mph	0.00 in.	4 (MG)	8%	13%	23	12%	25	3	516
Thu 10/28/21 2 am CDT	No	50°F	45%	NW	18 mph	0.00 in.	4 (MG)	8%	13%	22	11%	24	3	516
Thu 10/28/21 3 am CDT	No	49°F	47%	NW	18 mph	0.00 in.	4 (MG)	8%	13%	21	11%	23	3	516
Thu 10/28/21 4 am CDT	No	48°F	48%	NW	17 mph	0.00 in.	4 (MG)	9%	13%	20	10%	22	3	516
Thu 10/28/21 5 am CDT	No	48°F	49%	NW	18 mph	0.00 in.	4 (MG)	9%	13%	20	10%	22	3	516
Thu 10/28/21 6 am CDT	No	48°F	50%	NW	18 mph	0.00 in.	4 (MG)	9%	13%	20	9%	23	3	516
Thu 10/28/21 7 am CDT	No	47°F	50%	NW	18 mph	0.00 in.	4 (MG)	9%	13%	20	9%	23	3	516
Thu 10/28/21 8 am CDT	No	49°F	48%	NW	21 mph	0.00 in.	5 (G)	9%	12%	22	10%	28	3	516
Thu 10/28/21 9 am CDT	No	51°F	45%	NW	23 mph	0.00 in.	5 (G)	9%	12%	25	12%	32	3	516
Thu 10/28/21 10 am CDT	No	53°F	43%	NW	25 mph	0.00 in.	5 (G)	8%	11%	29	15%	38	4	516
Thu 10/28/21 11 am CDT	Yes	56°F	38%	NW	27 mph	0.00 in.	5 (G)	7%	11%	45	23%	65	6	516
Thu 10/28/21 12 pm CDT	Yes	58°F	34%	NW	29 mph	0.00 in.	5 (G)	7%	10%	60	30%	88	7	516
Thu 10/28/21 1 pm CDT	Yes	61°F	29%	NNW	31 mph	0.00 in.	5 (G)	6%	9%	71	37%	106	9	516
Thu 10/28/21 2 pm CDT	Yes	61°F	26%	NNW	31 mph	0.00 in.	5 (G)	6%	9%	77	41%	111	10	516
Thu 10/28/21 3 pm CDT	Yes	62°F	24%	NNW	30 mph	0.00 in.	5 (G)	5%	9%	81	44%	113	11	516
Thu 10/28/21 4 pm CDT	Yes	63°F	21%	NNW	30 mph	0.00 in.	5 (G)	5%	8%	84	47%	115	12	516
Thu 10/28/21 5 pm CDT	Yes	61°F	22%	NNW	28 mph	0.00 in.	5 (G)	5%	8%	82	45%	104	13	516
DATE / TIME	Criteria Met?	TAIR	RELH	WDIR	WSPD	1hr PRECIP	DISPERSION	1hr DFM	10hr DFM	BI	IC	SC	ERC	KBDI
Thu 10/28/21 6 pm CDT	Yes	59°F	23%	NNW	26 mph	0.00 in.	5 (G)	5%	8%	77	42%	93	13	516
Thu 10/28/21 7 pm CDT	Yes	57°F	24%	NNW	24 mph	0.00 in.	5 (G)	5%	8%	72	38%	81	12	516
Thu 10/28/21 8 pm CDT	Yes	56°F	25%	NW	23 mph	0.00 in.	5 (G)	5%	8%	68	35%	76	12	516
Thu 10/28/21 9 pm CDT	Yes	54°F	26%	NW	22 mph	0.00 in.	5 (G)	5%	8%	65	33%	70	11	516
Thu 10/28/21 10 pm CDT	Yes	53°F	27%	NW	21 mph	0.00 in.	5 (G)	6%	8%	61	31%	65	11	516
Thu 10/28/21 11 pm CDT	Yes	52°F	29%	NW	21 mph	0.00 in.	5 (G)	6%	8%	60	29%	64	10	516
Fri 10/29/21 12 am CDT	Yes	50°F	30%	NW	21 mph	0.00 in.	5 (G)	6%	8%	58	28%	63	10	516
Fri 10/29/21 1 am CDT	Yes	49°F	31%	NW	21 mph	0.00 in.	5 (G)	6%	8%	56	27%	62	9	516
Fri 10/29/21 2 am CDT	Yes	48°F	34%	NW	21 mph	0.00 in.	5 (G)	6%	8%	53	25%	59	9	518
Fri 10/29/21 3 am CDT	Yes	47°F	38%	NW	21 mph	0.00 in.	4 (MG)	7%	9%	50	23%	56	8	518
Fri 10/29/21 4 am CDT	No	46°F	41%	NW	20 mph	0.00 in.	4 (MG)	7%	9%	46	21%	51	7	518

Questions You Should Be Able to Answer by the End of this Module

- What are the two major adverse impacts of smoke?

- What is an inversion layer and what happens to smoke caught within it?

- Which of the six dispersion categories from the Oklahoma Dispersion Model are good for prescribed burning?

- How can the Fire Prescription Planner be used for prescribed burning?

QUESTIONS ?

Web Site Demo:
Dispersion Products and Fire Prescription Planner

OSU Online Prescribed Fire Course

Total Time Estimate: 8 hours

Topic Overview

- Introduction to Prescribed Fire
- Prescribed Fire Law and Liability
- Fire Prescriptions
- Fire Effects
- Firebreaks
- Ignition
- Smoke Management
- Burn Seasons
- Fire Equipment

https://learn.extension.okstate.edu

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Introduction to Prescribed Fire

Time limit: 120 days

$20 Enroll Now