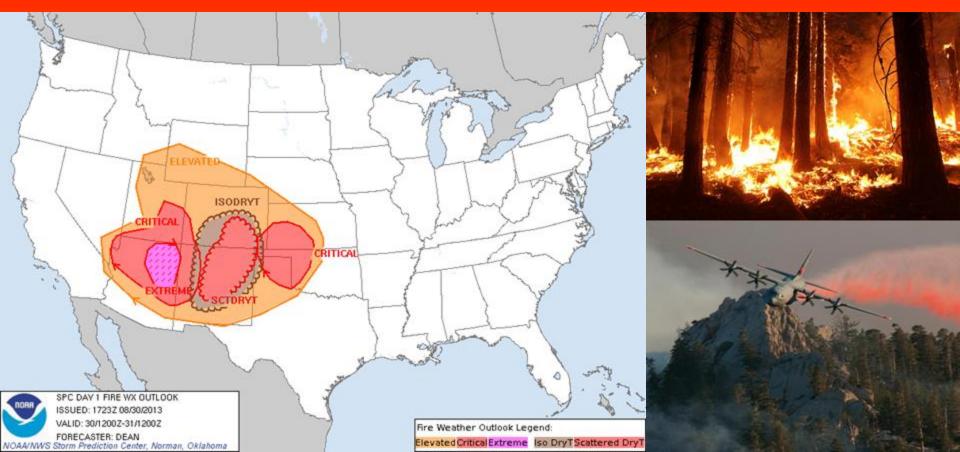
SPC Fire Weather Forecasts



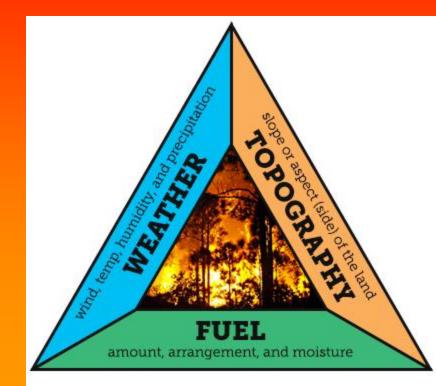
The Basics

- Like severe weather, fire weather can be thought of in an ingredients based framework.
- Ingredients can take several forms but the most common are:
 - Low humidity
 Low fuel moisture
 High winds
 Warm temperatures (optional)

The Two Triangles

FUEL

Combustion



Fire Behavior

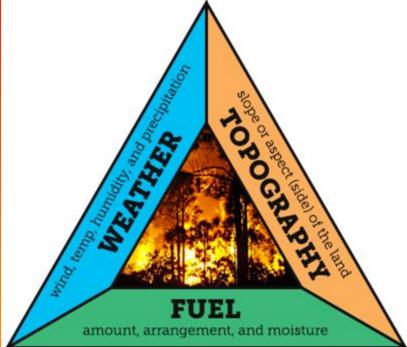
Combustion Triangle

Fire needs oxygen to burn, removing oxygen can extinguish a fire Fire requires heat to raise fuels to their ignition temperature. Cooling fuels can suppress a fire.

Fire needs something to burn! If there is no fuel (sticks, leaves, buildings), there can be no fire.

FUEL

Fire Behavior Triangle



Fuels influence:

- Fire intensity
- Rates of spread
- Probability of ignition

Topography influences:

- Fire movement
- Preheating of fuels
- Fuel dryness

Weather influences:

- Fire movement
- Plume structure
- Probability of ignition
- Rates of spread

Topography



Rate dynamics and in the second states

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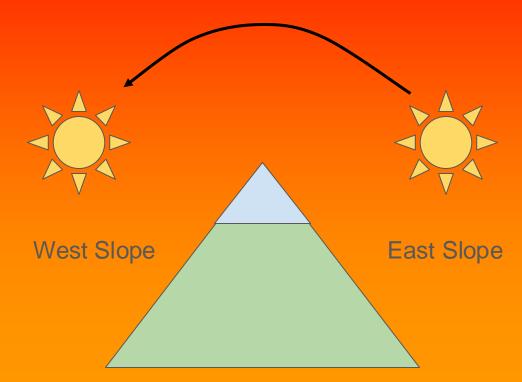
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P. Series Scherberteiler, anderes A. Standardskaf, Santa S. Status S. 2018, 2018 Status Stream Status Status, 2018 Stream Status Status, 2018 Stream Status Status Status Sciences Status Status Sciences Status Status





Topographic Influence



East Slope:

- Warms earlier in the morning
- Cools earlier in the evening.

West Slope:

- Warms later in the morning
 - Cools later in the evening.

Topographic Influence



- Receives more sunlight throughout the year*
- Leads to drier fuels than other slopes

South Slope

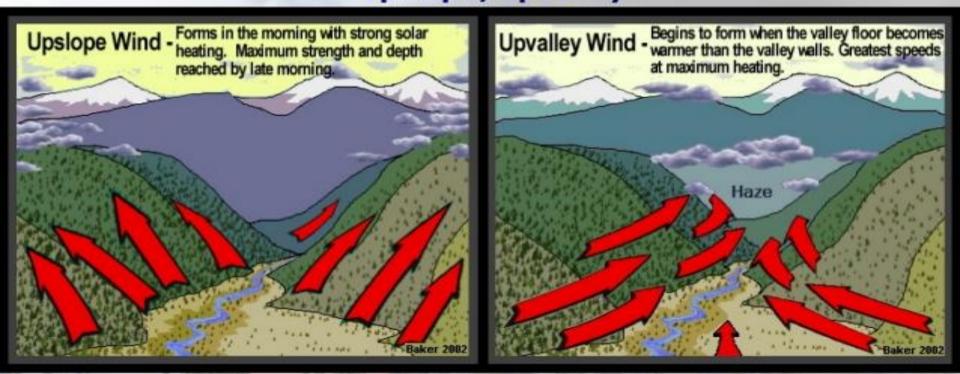
North Slope:

- Receives less sunlight throughout the year*
- Leads to more moist fuels than other slopes

*In the northern hemisphere!

North Slope

Local Winds



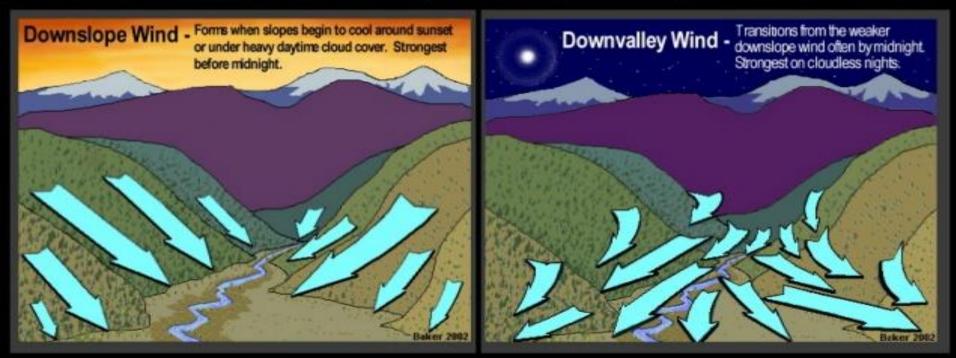
Early to Mid-Morning- 3 to 8 mph

Unit 7

Late Morning and Afternoon- 10 to 15 mph

Wind Systems

Local Winds Downslope/Downvalley



Late Afternoon and Evening- 2 to 5 mph

Unit 7

ntermediate

Late Evening and Overnight- 5 to 10 mph

Wind Systems

Slope affects fire behavior

Fresh air

Burning chunks Rolling down slope

draft

Faster ignition and spread

preheating

NWCG

Quiz Time!

I'll show you a picture - you decide where in the U.S. the picture is from.

Picture 1



U.S. Department of the Interior U.S. Geological Survey

The Geographic Face of the Nation – Elevation

3

Southern CA



Rest of party in the second distance of the second second

Ver LTS, Confegited Terrory, PTELT has mendanting a security of parameters dependent data due of early calculated bases. New Antidence Medications Debugses, 2015; one approximate data on early the ME and the dependent dependent dependent and the Antidence Medication and an early dependent data dependent dependent dependent dependent dependent constructions and provident and the construction of the Antidence Terror Medication in Antidence Medication and a provident dependent dependent dependent constructions and a second and a provident dependent dependent dependent dependent Medications in the importance and a provident dependent dependent dependent dependent dependent in the importance and a specification dependent depende

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Picture 2



U.S. Department of the Interior U.S. Geological Survey

The Geographic Face of the Nation – Elevation

Smoky Mtns. National Park





Rest diameter and in cases

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This MED'R processed is the problem for a functional campo of some technicing functioning workfilling and soft integrating finds and problem campoint and assess to the VEER and available do to THEP with the Stage July data and any model.

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Picture 3



U.S. Department of the Interior U.S. Geological Survey

The Geographic Face of the Nation – Elevation





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Picture 4



U.S. Department of Six Interior U.S. Geological Survey

The Geographic Face of the Nation – Elevation

Southern FL



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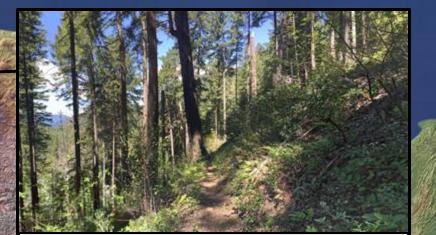
ô----

Picture 5



U.S. Department of the Interior U.S. Geological Survey

The Geographic Face of the Nation – Elevation



Willamette National Park, OR



Rest diameter and in cases

Vice 1.12, includingly difference of TRUE has considered a secondary displayed in the proceeders stands that the formation in the action in the data of the data of the data of the theory of the data of the secondary data of the constraints of the data of the constraints of the data of the constraints of the data of the constraints of the data of t

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Fuels - Will they burn?



Forecasting Fuels: Fuel Types

• A fuel's time lag classification is proportional to its diameter and is loosely defined as the time it would take for 2/3 (67%) of the dead fuel to respond to atmospheric moisture.

• For example, if a fuel had a "1-hour" time lag, one could expect its wildfire susceptibility to change after only 1 hour of humid weather.

TIME LAG	FUEL SIZE	DETERMINATION		
1-hour	<0.25 inch diameter	Fine flashy fuels that respond quickly to weather changes. Computed from observation time temperature, humidity, and cloudiness.		
10-hour	0.25 to 1 inch diameter	Computed from observation time temperature, humidity, and cloudiness. Can also be an observed value, from a standard set of fuel sticks that are weighed as part of the fire weather observation.		
100-hour	1 to 3 inches diameter	Computed from 24-hour average conditions composed of day length, hours of rain, and daily temperature/humidity ranges.		
1000-hour	3 to 8 inches diameter	Computed from a 7-day average conditions composed of day length, hours of rain, and daily temperature/humidity ranges.		

Spring – Grass Calibration

GRASS (Spring)	ISI < 2.0	ISI 2 to 5.9	ISI 6.0 to 7.9	ISI 8.0+
FFMC < 86.0	LOW	MODERATE	MODERATE	VERY HIGH
FFMC 86.0 to 91.9		MODERATE	HIGH	VERY HIGH
FFMC 92.0+ & FWI < 36.0			VERY HIGH	VERY HIGH
FFMC 92.0+ & FWI 36.0+				EXTREME

Fuel indices

- ERC (Energy Release Component)
- BI (Burning Index)
- Fossberg Index
- Haines index
- Spread Component (SC)
- FFMC (Fine Fuel Moisture Code)
- HDWI (Hot Dry Windy Index)

As with severe parameters, use with caution! Composites can lead you astray!



Fire Weather Indices: ERC SC and BI

Energy Release Component (ERC) is a calculated output of the National Fire Danger Rating System (NFDRS). The ERC is a number related to the available energy (BTU) per unit area (square foot) within the flaming front at the head of a fire.

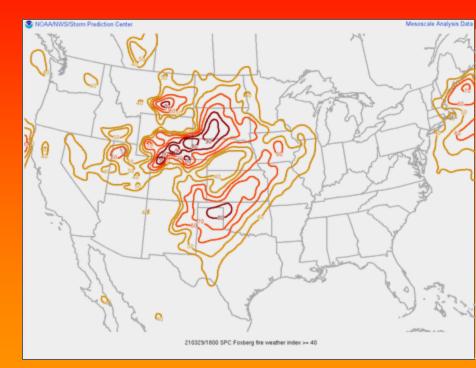
Spread Component (SC) "the spread component is numerically equal to the theoretical ideal rate of spread expressed in feetper-minute.

Burning Index (BI) is a number used by the National Oceanic and Atmospheric Administration (NOAA) to describe the potential amount of effort needed to contain a single fire in a particular fuel type within a rating area. The National Fire Danger Rating System (NFDRS) uses a modified version of Bryam's equation for flame length – based on the Spread Component (SC) and the available energy (ERC) – to calculate flame length from which the Burning Index is computed.^[1]

$$BI=j_1\;F_L$$
 $F_L=j\left[\left(rac{SC}{60}
ight)\left(25(ERC)
ight)
ight]^{0.46}$

Fire Weather Indices: Fossberg FWI

- It is a non-linear filter of meteorological data developed by first transforming temperature and relative humidity to equilibrium moisture content, then transforming the equilibrium moisture content to combustion efficiency. The index is approximated by F = D((Rate of Spread) (Energy Release)) ^0.46
- Scaled to represent 0% moisture with a 30 mph wind.
- Values of 0-100, greater than 50 is considered significant.
- Most commonly used for strong wind driven fire events. (Plains/Southeast)



Fire Weather Indices: Haines Index

- Haines index is a multi regional fire weather tool used to assess the likelihood of plume dominated fire behavior from atmospheric stability and moisture.
- Hi = Stability term + Moisture term
- Stability term = T1 T2
- Moisture (Td Depression) Term =T1 Td1
 - Each term is scored based on the values. The added scores are the final haines index value.

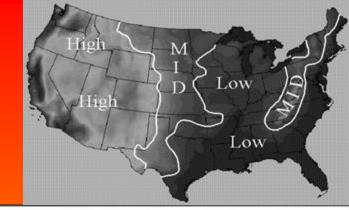


table 1 : CALCULATION of the HAINES INDEX

LEVEL	STABILITY TERM	STABILITY SCORE	MOISTURE TERM	MOISTURE SCORE
LOW	950hPa Temperature - 850hPa Temperature =< 3 degrees C 4 to 7 degrees C => 8 degrees C	1 2 3	850hPa Temperature - 850hPa Dewpoint =< 5 degrees C 6 to 9 degrees C => 10 degrees C	1 2 3
MID	850hPa Temperature - 700hPa Temperature =< 5 degrees C 6 to 10 degrees C => 11 degrees C	1 2 3	850hPa Temperature - 850hPa Dewpoint =< 5 degrees C 6 to 12 degrees C => 13 degrees C	1 2 3
HIGH	700hPa Temperature - 500hPa Temperature =< 17 degrees C 18 to 21 degrees C => 22 degrees C	1 2 3	700hPa Temperature - 700hPa Dewpoint =< 14 degrees C 15 to 20 degrees C => 21 degrees C	1 2 3

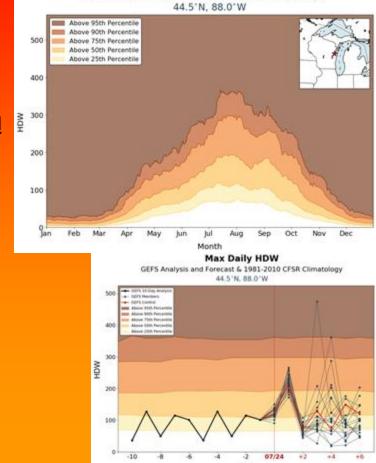
Fire Weather Indices: HDWI Hot Dry Windy Index

"HDW was designed to be very simple – a multiplication of the maximum wind speed and maximum vapor pressure deficit (VPD) in the lowest 50 or so millibars in the atmosphere. <u>Because HDW is affected by heat, moisture, and</u> wind, seasonal and regional variability can be found when comparing HDW values from different locations and times."

HDW = Wmax * VPD

Wmax = 50 mb max wind

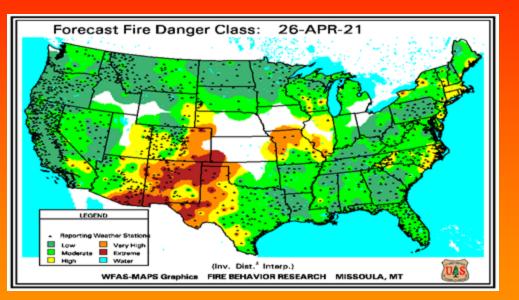
VPD = Es - E Vapor Pressure deficit. Very similar to RH



Day

Max Daily HDW, 1981-2010 CFSR Climatology

National Fire Danger Rating System (NFDRS)



A fire assessment system used to provide a daily estimate of wildfire risk.

This uses a system of equations with variables that include weather inputs, topography, and fuel types to determine the fire danger category.

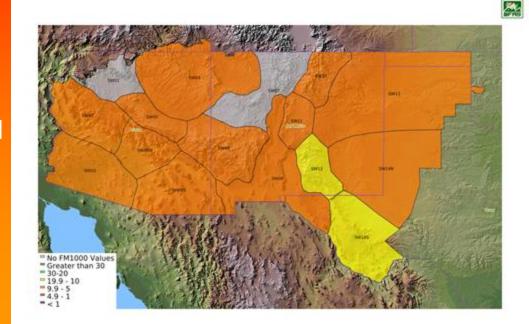
Easy-to-interpret categories allow for easier communication of fire risk.

Fine Fuel Moisture Code FFMC

The Fine Fuel Moisture Code (FFMC) represents fuel moisture of forest litter fuels under the shade of a forest canopy.

It is intended to represent moisture conditions for shaded litter fuels, the equivalent of 16-hour timelag. It ranges from 0-101. Subtracting the FFMC value from 100 can provide an estimate for the equivalent (approximately 10h) fuel moisture content.

Most accurate when FFMC values are roughly above 80.



Forecasting Fuels



- Geographic Area

 Coordination Centers
 predictive service
 specialists produce fuel
 and fire forecasts for
 specific areas of the US.
- Controlled by the National interagency Fire Council (NIFC)
- Planning levels determine the threat on a scale of 1 to 5.

Basic Fire Weather Forecasting Workflow

Narrow your focus

Begin looking for more focused/intense fire weather corridors. Forecast soundings offer a great tool to quickly assess stability and fire danger. Look more closely at the fuels. How dry are they?

The "Big Picture"

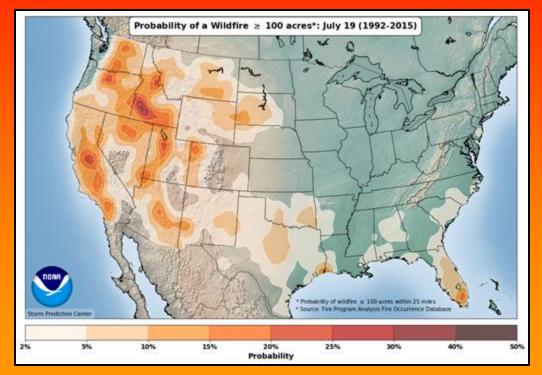
Start with a broad overview of the synoptic weather conditions. Know
the climo. Find your major features.
Do a quick fuels assessment. Look for favorable fuel areas. Get rid of any areas with QPF greater than .25 inches over the last 1-2 days.

The details

Really dive into the areas of potential concern. Look for terrain features using land-use maps. FInd the fuel rich areas and assess the conditions over them. HREF and cams can give you powerful details on wind/RH combos. Remember to only draw where fuels can burn. Urban/wilderness interfaces.

Climatology

When and where do big fires occur?



https://youtu.be/Zr5-H6j9f7A

Fire Weather Regimes

Critical Fire Weather Patterns of the United States



Reference: National Weather Service's (NWS) Fire Weather Forecasters Course Presented at Boise March 30 – April 2, 1999.

- See this document for an excellent dive into different types of fire weather patterns.
- A variety of fire weather regimes exist across the CONUS.
- Every state has some sort of fire weather pattern or response.
- Much of the western CONUS is the "big leagues" for fire weather forecasting.
- Internationally: Australia, Brazil, Portugal/Spain, Russia, Indonesia, and others are among some of the most active fire weather areas in the world.

Disclosiner: This document was seconned into a WORD document and converted to a PDF format. Care was taken to ensure conversion was accurate but errors may have introduced by the OCR process.

Fire Weather Regimes

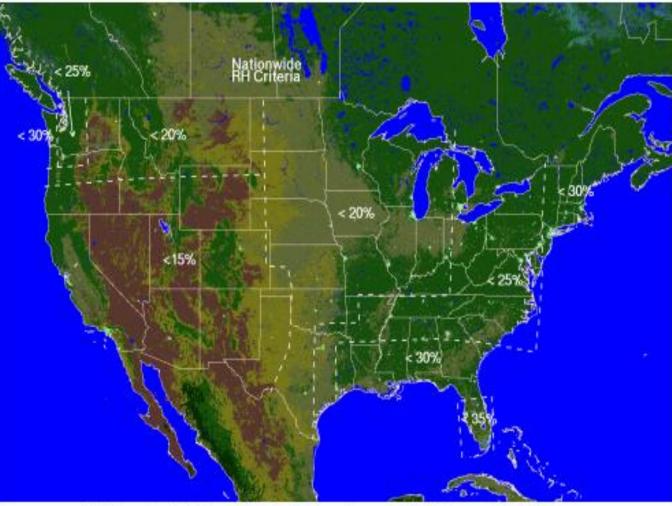
Critical Fire Weather Patterns of the United States



Reference: National Weather Service's (NWS) Fire Weather Forecasters Course Presented at Boise March 30 – April 2, 1999.

Disclaimer: This document was scanned into a WORD document and converted to a PDF format. Care was taken to ensure conversion was accurate but errors may have introduced by the OCR process. Keep in mind the fire weather ingredients:

 Low humidity
 Low fuel moisture
 High winds
 Warm temperatures (optional)



RH thresholds for critical designation overlaid on a landuse map

Red Flag Warnings
have different
thresholds for
different areas of the
country.

Why?

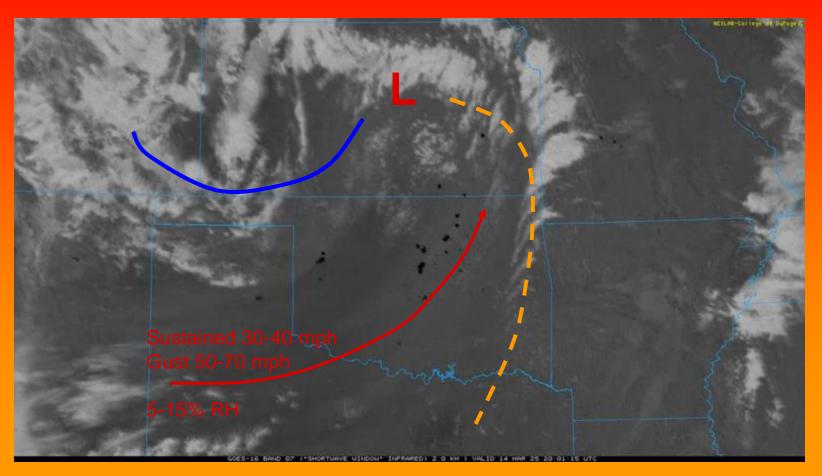
- Variety of fuels
- Variety of land use
- These differences are driven by:
 - Terrain
 - Precip distributions

Southern Plains

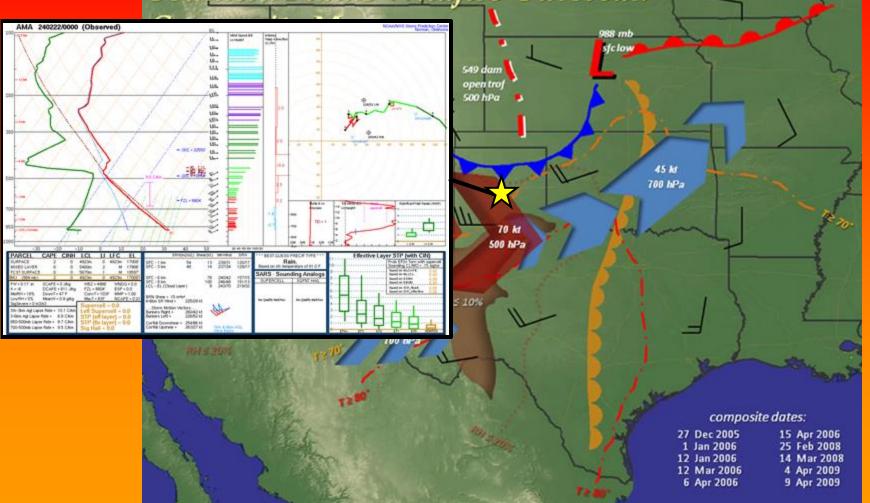


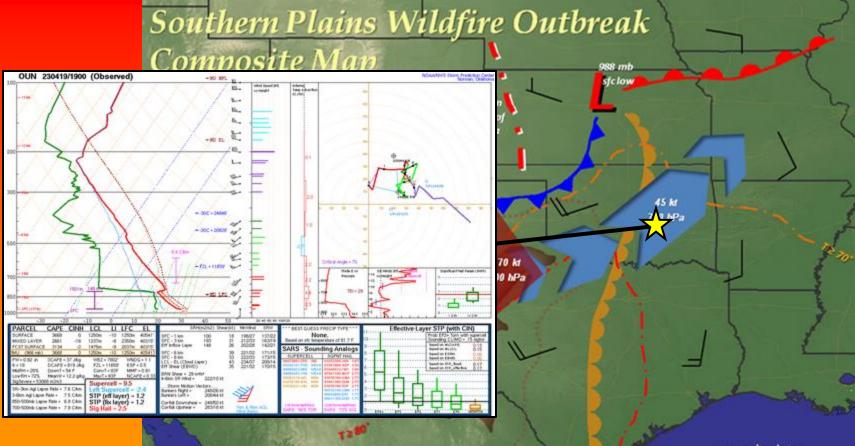
- Dominated by fast moving shrub and grass fires.
- Occur ahead of deep 500 mb troughs with strong low and mid-level flow.
- Dryline acts as eastward boundary.
 - Most common during the "pre and post greenup" periods of late winter/ early spring and early to mid fall.
- Western US drought usually a significant predictor.

Southern Plains Fire Outbreak - March 14, 2025



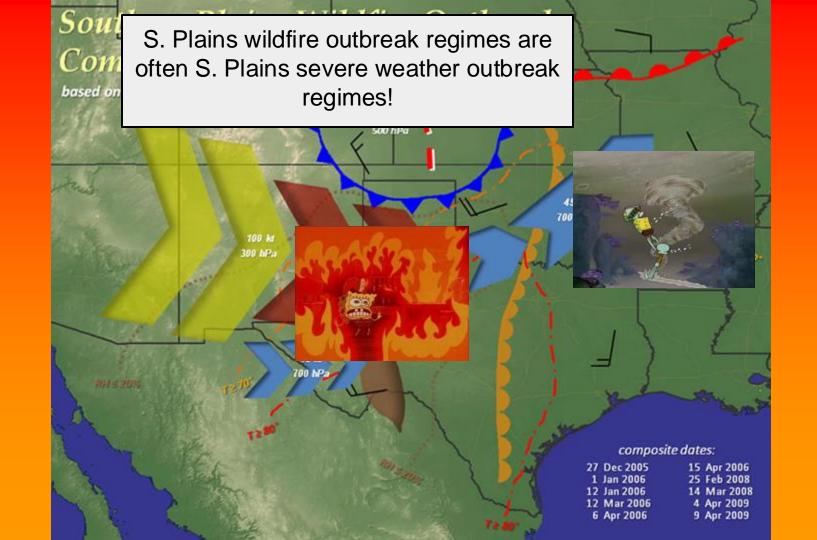
Southern Plains Wildfire Outbreak



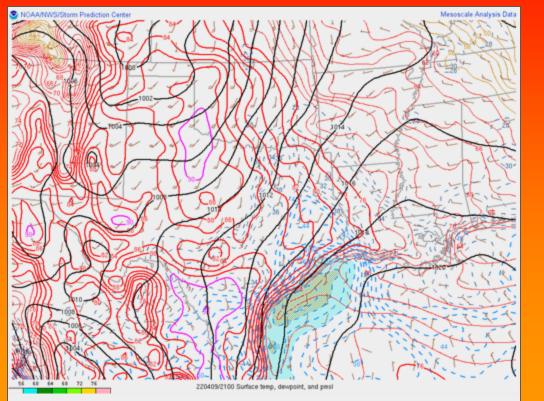


composite dates:

27 Dec 2005	15 Apr 2006
1 Jan 2006	25 Feb 2008
12 Jan 2006	14 Mar 2008
12 Mar 2006	4 Apr 2009
6 Apr 2006	9 Apr 2009

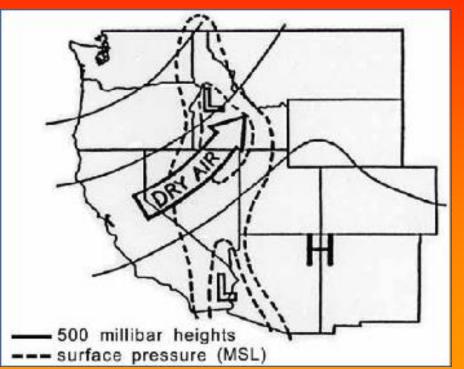


Southern Plains - Dry Return Flow



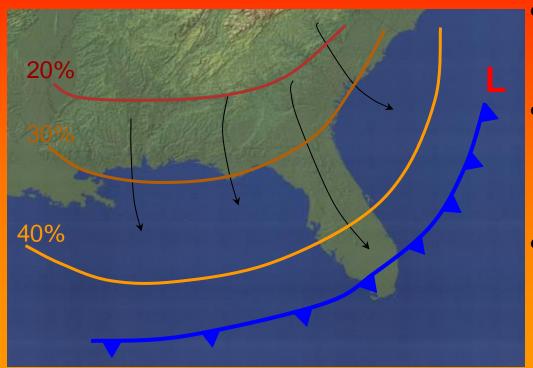
- Dry return flow is characterized by gusty southerly winds across the southern and central High Plains in the absence of deep gulf moisture.
- Usually driven by low-amplitude mid-level troughs crossing the Rockies.
- Enhanced by lee troughing/cyclogenesis, surface winds of 20-30 mph are common.
- Low- level thermal ridge contributes to low RH (<20%)

Rockies and Southwest



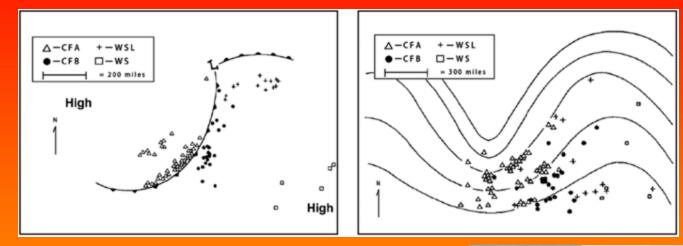
- "Big Bubble no Trouble" -An old forecasterism also known as ridge breakdown
- A mid-level ridge is broken down (partially or fully) by an advancing shortwave trough.
- A deceptive pattern with important implications for fire potential.
 - Winds aloft may not be that strong.
 - Quiescent but hot weather
 - Dry frontal passages
 - Dry Thunderstorms and gusty outflow
- Very common throughout summer and early fall before and after Monsoon.

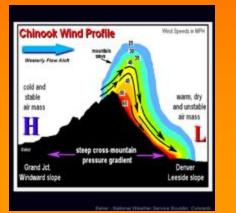
Southeastern U.S.



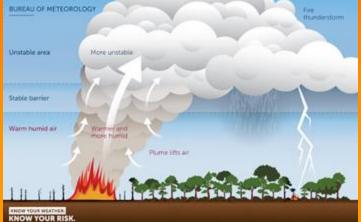
- Northerly winds behind a cold frontal passage ushers in drier air.
- Relative Humidity values may be higher than you would expect (30-40%)
- Winds may be lighter than normally expected (15-20 mph)

Smaller-Scale Details

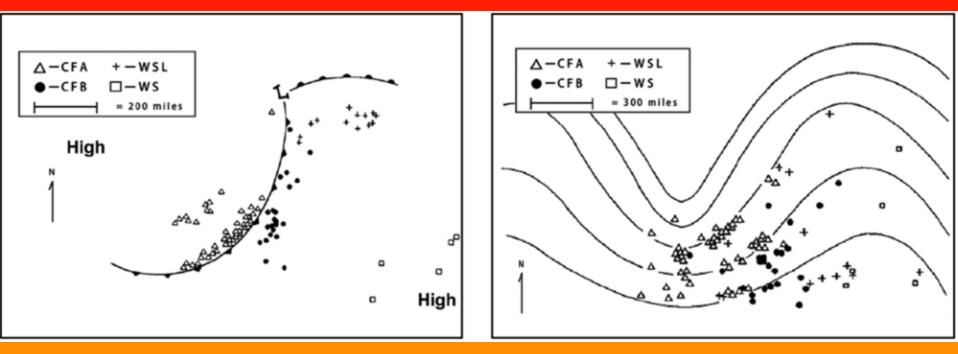






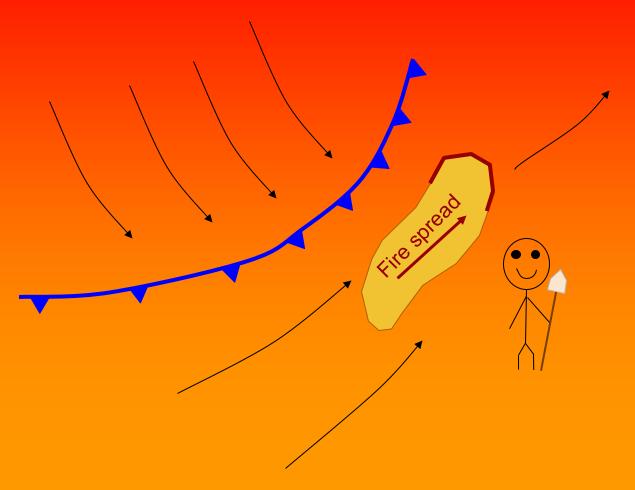


Dry Cold Fronts

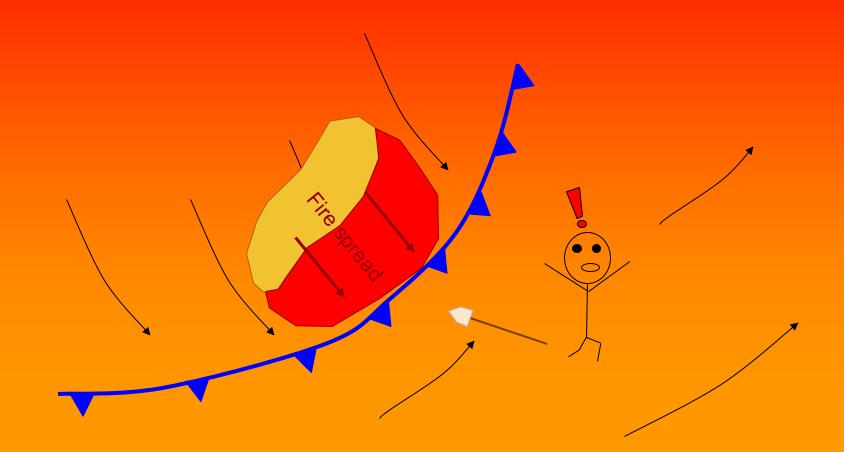


- Cold fronts producing very little rainfall but strong wind shifts.
- Common across the western US and southern Plains.
- Can cause rapid fire spread/spotting.
- South Canyon Fire (Storm King Mountain Colorado burnover 14 smoke jumpers killed)

Dry Cold Front Fire Direction Changes



Dry Cold Front Fire Direction Changes

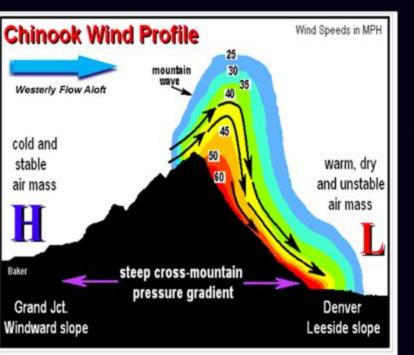


Dry Cold Front Fire Direction Changes March 6-7, 2017 S. Plains Wildfire Outbreak



https://www.youtube.com/watch?v=h11A0zbCrM0&t=1s

Lee of the Rockies



Chinook Wind

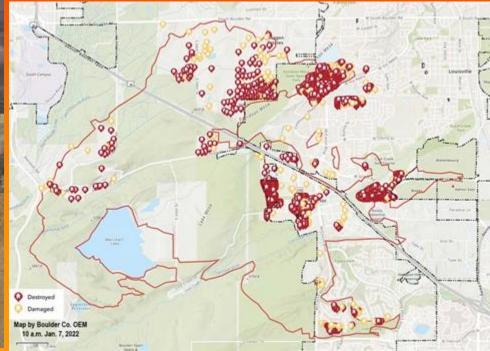
Steep pressure gradient (or large horizontal difference in air pressure) between a pressure maxima or high pressure (H) in western Colorado and a pressure minima or low pressure (L) in northeast Colorado is necessary for the formation of strong and gusty Chinook winds on and near the east face of the Front Range. Strong westerly flow aloft will further strengthen this downslope wind.

- Downslope winds
- Common through Colorado Wyoming and Montana.
 - Weaker during the summer when flow retreats
 northward but early/ late
 Season Events (Aug-Oct & May-June) can drive very
 strong wildfire events.
- Winds may exceed 150 mph through terrain gaps and at ridge top level.

2022 Marshall Fire boulder County, CO



- Unusual time of year Dec 31-Jan downslope wind storm gusts to 115 mph supported rapid spread.
- \$513+ million in damages.
- 1k structures destroyed and 6k acres 2 fatalities.
- Most damaging fire in CO history after only 12 hours.
- Exacerbated by expanding Wildland Urban Interface and poor open space management practices.

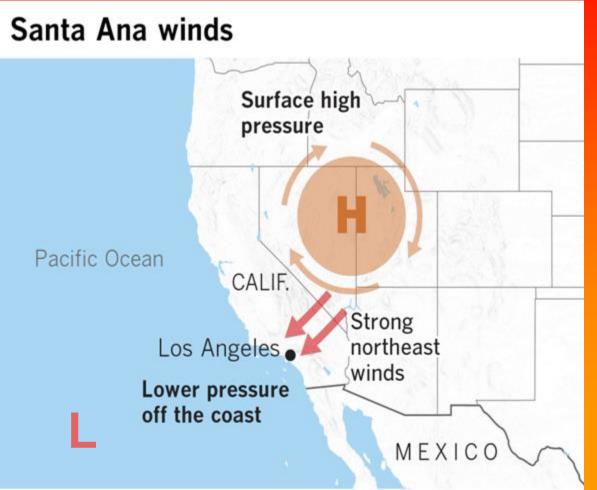


California

TCW Rooftop, /7/2025 5:47:35 PM

e Cod

Santa Anas



- A localized type of Foehn wind driven by offshore pressure gradients.
- Adiabatic drying and advective drying over the Great Basin produce extremely low RH as low as 1-3%
- Winds may exceed 80 mph through terrain and gaps.
- Extreme fire behavior develops as a combination of very combustible fuels and extreme winds.

S-290

Critical Winds Foehn Winds

Santa Ana Winds

- Originates in the high deserts of southern California.
- steep pressure gradient exists between high pressure in the Great Basin and low pressure off the coast of southern California.
- Downslope off shore flow develops.
- Can create critical fire weather situations in southern California.



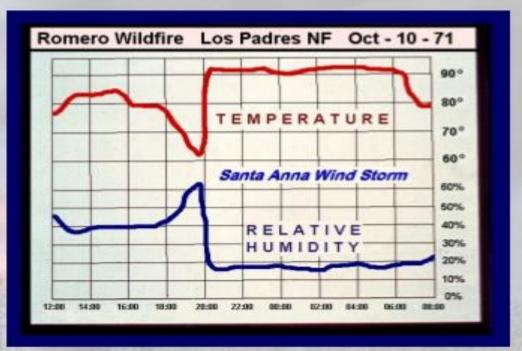
ntermediate Wildland Fire Behavior

S-290

Critical Winds Santa Ana Wind Storm

Santa Ana Wind Storm

- Romero fire October 10, 1971
- Note the sudden temperature rise and RH drop when the Santa Ana winds develop



What creates dangerous winds

The excessive

wind can cause

power lines to

spark, setting

topple and

fires.

The Diablo winds that were forecast for Northern California usually come in the fall, but their behavior is hard to predict because mountains, valleys and even cloud formations can alter their speed and directon.

G Squeezing through

the coastal mountain

ranges, wind speed is

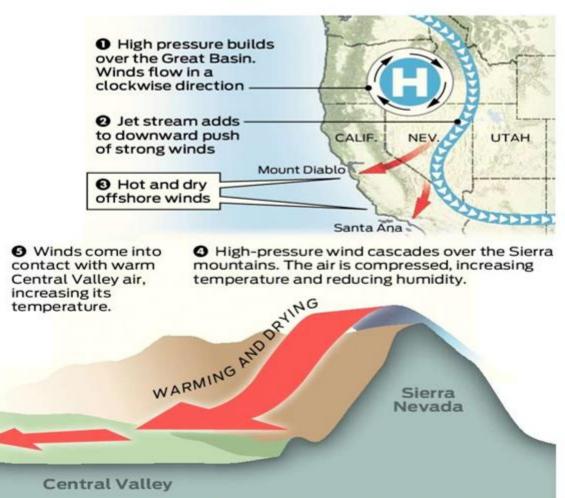
WARMING AND OPTING

Coastal range mountains

to over 40 mph.

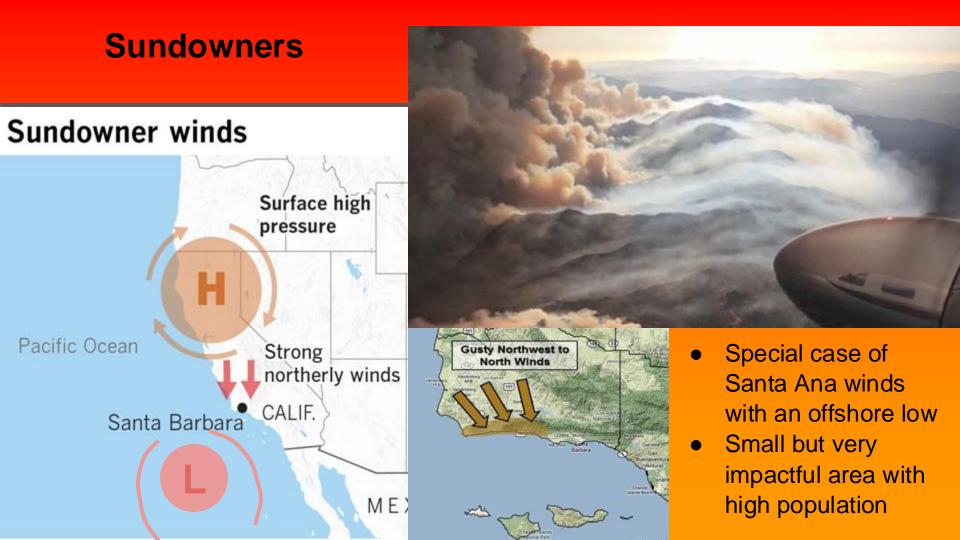
dynamically increased

canyons and gaps of



Sources: National Weather Service; NOAA

John Blanchard / The Chronicle





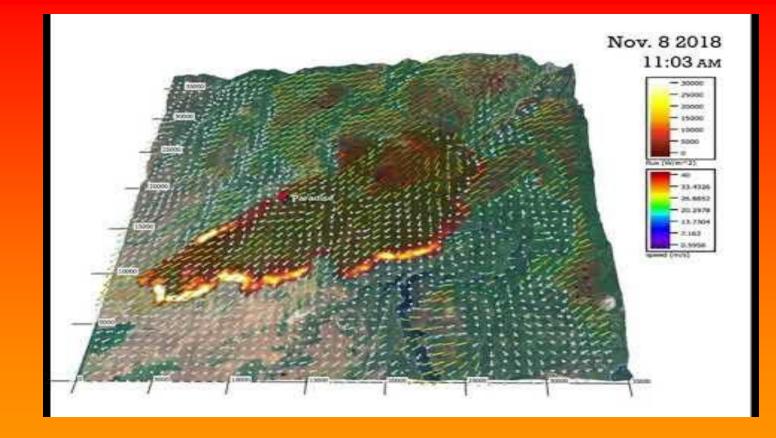
Camp Fire Nov 2018

153,000 Acres

18,000 Buildings Destroyed

85 Fatalities \$16.5 Billion





https://www.youtube.com/watch?v=dyfJYOZgiyA

5-15% RH

Sto 2 mo DACIAN DESSUE OF BURGHER 50-80 mph downslope winds

Palisades & Eaton Fires January 2025

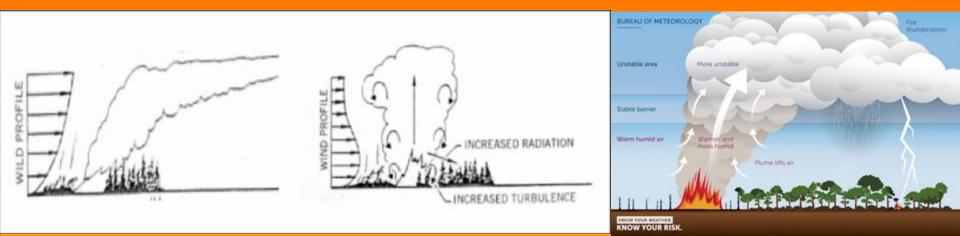
29 Fatalities

~18,000 Structures damaged or destroyed



"Plume Dominated" vs "Wind Driven" events

- Prototypical fire regimes are often characterized by warm temperatures, low relative humidity, and strong boundary-layer winds. AKA "<u>Hot Dry Windy</u>"
- Low RH cures fuels by increasing the potential energy of a material. High winds bring oxygen and spread flames/sparks creating spot fires. Literally fanning the flames.
- Just like thunderstorms atmospheric instability can also drive fire weather. Hot dry and unstable conditions can be just as dangerous as hot dry and windy.
- Fires can create their own environment from strong buoyant updrafts collapsing and reforming.
- Plumes can loft embers for miles and create strong inflow/outflow winds on collapse leading to long range spotting, new fires, and rapid burnovers.



Pyro Cumulus

Station/Gak Glen/ Angeles National Forast Fire | \$5.35.2535



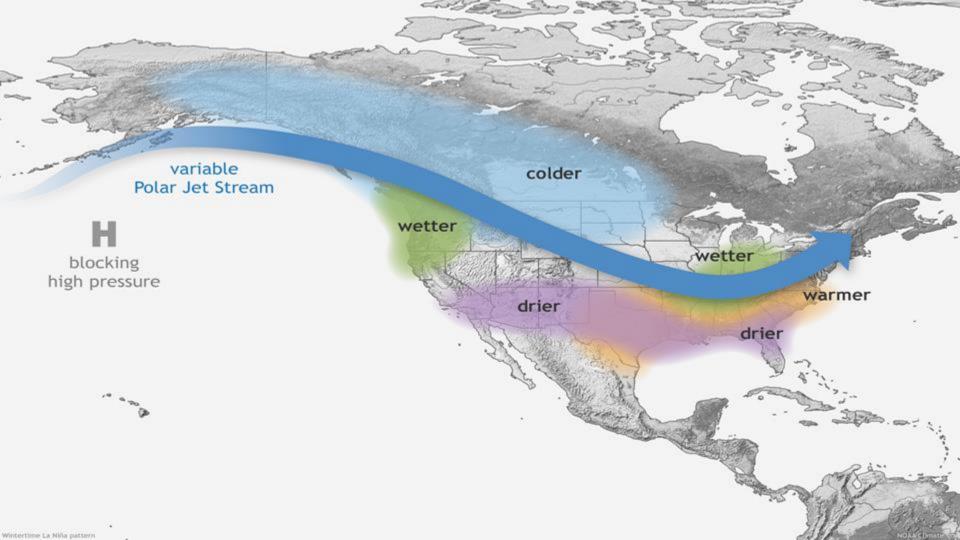


Other less common patterns

 In the northern plains, Great Lakes, and the northeastern US, pre-frontal high pressure from the Pacific, Northwestern Canada, and Hudson Bay all can produce very dry conditions. Cold fronts produce relatively short lived periods of high winds and instability that can produce extreme fire behavior.

 In the southeastern US, drought is frequently associated with the La Niña state of the southern oscillation pattern or a blocking ridge aloft near the Atlantic coast. Often critical weather patterns follow the frontal passage that brings extremely dry air due to a strong westerly or northwesterly flow. Look for strong winds that accompany the flow. Beware of advancing tropical storms as well as sea breeze boundaries across Florida.



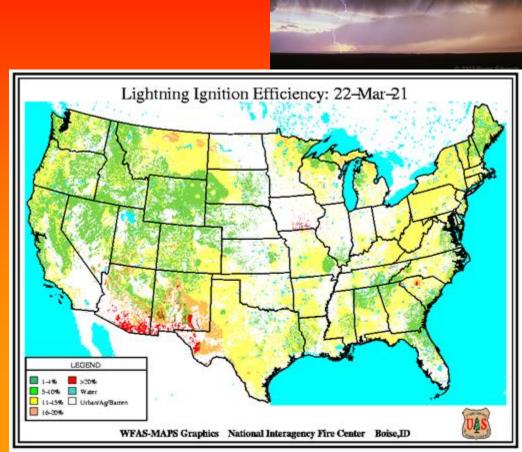


Dry Thunderstorms

 A fast moving or high based thunderstorm producing cloud to ground lightning and less than 0.10 inches of precipitation accumulation in 1 hour.

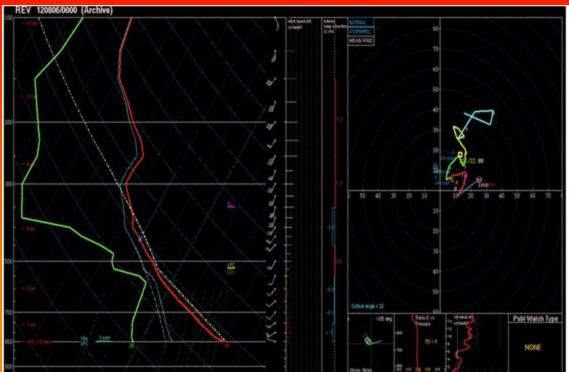
• Lightning ignitions account for a significant fraction of wildfires.

 Climate change suggests dry thunder/lightning ignition outbreaks may increase.



Dry Thunderstorms

- Deep and dry boundary layer. As much as 5-600 mb!
- Mid Level moisture advection results in destabilization. PW values of 0.5 to 0.75 inches most common
- Low CAPE and low shear (storms move slowly)
- Mixed storm modes most frequent



Thunderstorm Mode	Precipitation Amounts (in.)	Characteristic PW Values (in.)	
Dry	0.00-0.10	0.50-0.75	
Mixed Wet-Dry	0.10-0.20	0.75-1.00	
Wet	>0.20	>1.00	

S-290

Critical Winds Thunderstorm Winds

Wind Systems

Gust Front

- Leading edge of the downdraft
- Boundary between two dissimilar air masses, similar to a cold front
- Most of the time, marked by a wind shift, decrease in temperature

Unitand increase in



2 minutes

S-290

Critical Winds Thunderstorm Winds

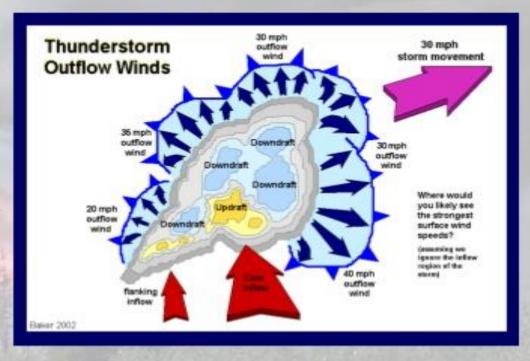
dland Fire Behavior

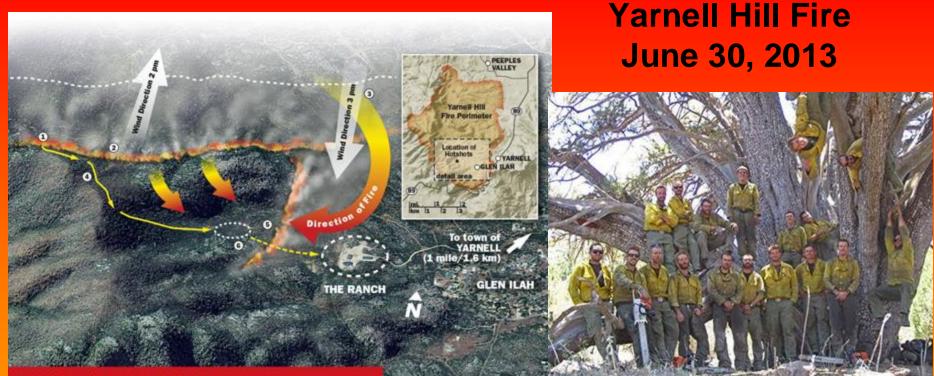
Outflow Winds

 Outflow wind strongest in the direction the storm is moving

ntermediate

 Outflow wind weakest in the opposite direction the storm is moving





CAUGHT IN THE CANYON

 9:30 AM: After hiking up from the subdivision of Glen Ilah, the Hotshots begin digging lines and clearing brush to contain the fire, which at this point had burned 150 acres. 2. Until 3 PM a wind from the southwest pushed the flames north.
 The wind shifts direction and begins blowing from the northeast, propelling the fire down toward the Hotshots. Lookout Brendan McDonough's position comes under threat, and he is instructed to leave his post. 4. Approximately 4 PM: The Hotshots leave the fireline and head east. They drop into the canyon toward the safety of the ranch, a half mile away, losing their view of the blaze as the fire accelerates. 5. Fire reaches the eastern end of the canyon, trapping the firefighters

- Ignited by dry lightning
- Erratic behavior on June 30th due to outflow winds

SPC Fire Products

Fire Weather Outlooks

The Fire Weather Outlooks are intended to delineate areas of the continental U.S. where pre-existing fuel conditions, combined with forecast weather conditions during the next 8 days, will result in a significant threat for the ignition and/or spread of wildfires. This product is designed for use in the NWS, as well as other federal, state, and local government agencies.

Each outlook consists of a categorical forecast that graphically depicts fire weather risk areas across the continental United States, along with a text narrative. Through various labels and colors on the graphic, the five types of Fire Weather Outlook risk areas are:

- ELEVATED (orange) Elevated risk from wind and relative humidity
- CRITICAL (red) Critical risk from wind and relative humidity
 EXTREME (magenta) Extremely Critical risk from wind and relative humidity

ISODRYT (brown) - Elevated risk from dry thunderstorms **SCTDRYT** (red) - Critical risk from dry thunderstorms

Fire Weather Outlooks

Updated: Sun Mar 7 17:01:03 UTC 2021 (2h 8m ago)

Storm Prediction Center Mesoscale Assistant/Fire Weather Forecaster Ariel Cohen describes the SPC fire weather forecast process for a meteorology class at the University of Oklahoma. You can view the YouTube video: https://youtu.be/Xy9AdUaUynU.

Current Fire Weather Outlooks (Product Info)

Current Day 1 Fire Weather Outlook



Forecaster: SQUITIERI Issued: 071659Z Valid: 071700Z - 081200Z Forecast Risk of Fire Weather: Critical Risk Note: Critical Fire Weather Criteria document in MS-Word or PDF.

Current Day 2 Fire Weather Outlook



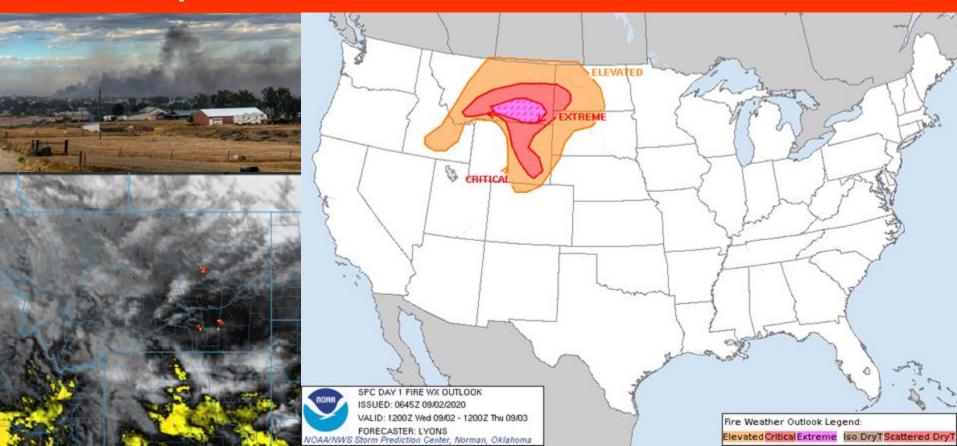
Forecaster: MOORE Issued: 070729Z Valid: 081200Z - 091200Z Forecast Risk of Fire Weather: Elevated Note: Critical Fire Weather Criteria document in MS-Word or PDF.

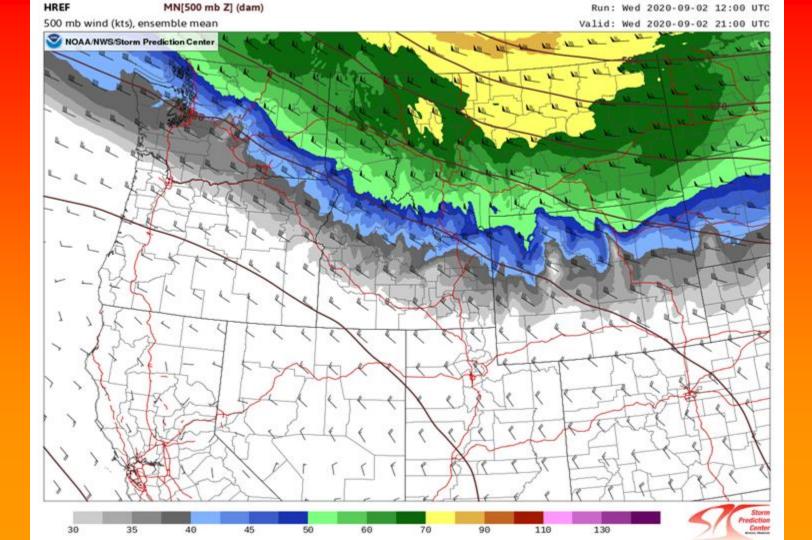


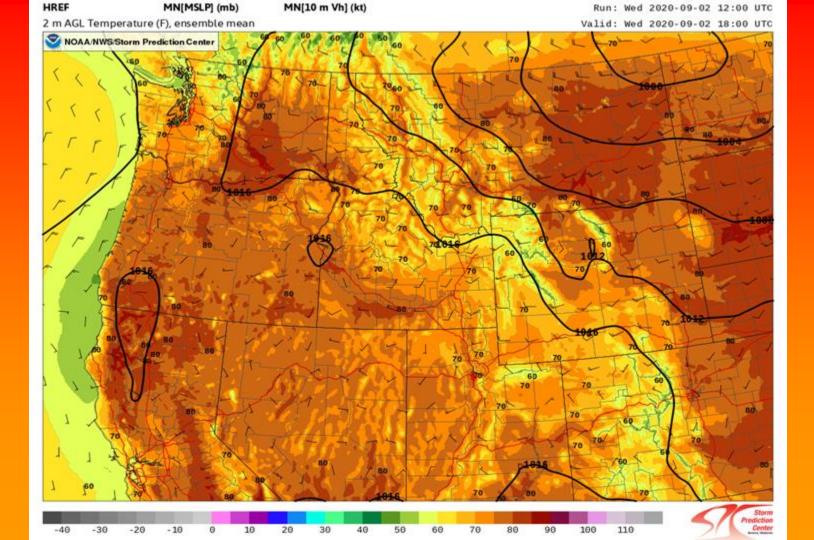
Day 3-8 Fire Weather Outlooks (Product Info)

Forecaster: SQUITIERI Issued: 062159Z Valid: 08/1200Z-14/1200Z

September 2nd 2020 Montana fire outbreak



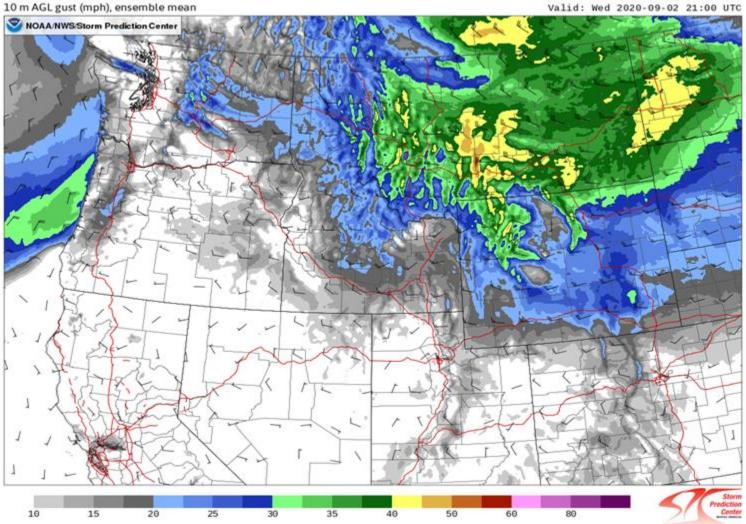






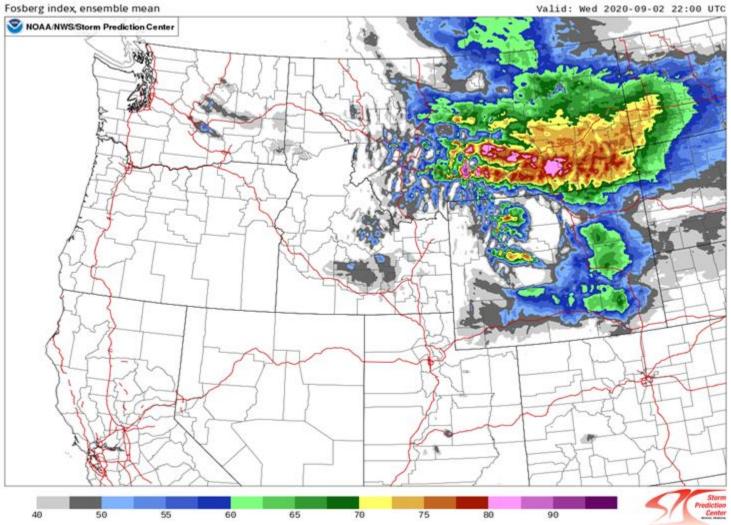
MN[10 m Vh] (mph)

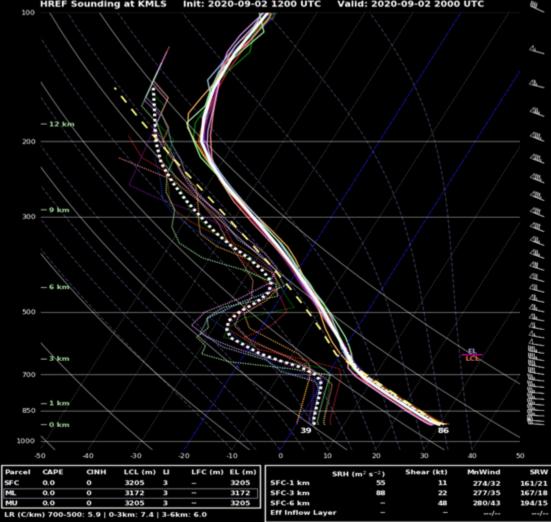
Run: Wed 2020-09-02 12:00 UTC Valid: Wed 2020-09-02 21:00 UTC

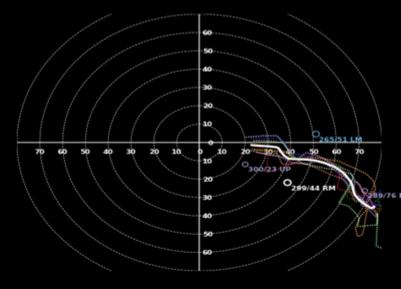




Run: Wed 2020-09-02 12:00 UTC Valid: Wed 2020-09-02 22:00 UTC







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Wrap Up

- Fire weather can be thought of in an ingredients based framework.
- Fuels are one of the most important but difficult aspects of forecasting.
- Forecasting should follow a similar flow to severe weather.
 - Big Picture
 - Narrow your focus
 - The details
- Fire weather regimes vary widely across the CONUS.
- Fire weather is one of the most difficult and poorly understood aspects of severe weather forecasting.