Burn Planning: Interpreting Weather and Writing Prescriptions

Broadcast burning is an effective way to manage vegetation and mitigate wildfire risk on your property. Understanding how weather conditions impact the safety, feasibility, and efficacy of your burn and selecting suitable burn windows are essential elements to conducting successful broadcast burns. One element of a broadcast burn is developing a **prescription**, or a set of specific weather parameters under which you plan to safely and effectively conduct a burn. **This factsheet provides an overview of critical weather parameters that drive fire behavior and provides suggestions for weather-related resources you can consult when developing your burn prescription.** For specific questions about your prescription and interpreting local weather forecasts, please contact your local prescribed burn association, UCCE fire advisor, fire department, or CAL FIRE unit.

When permits are required from your local fire suppression agency, they may require you to develop a written document (or **burn plan**) that provides a description of the burn area, target weather conditions (a prescription), burn unit preparation, crew and equipment resources needed, as well as safety and logistical factors to consider before, during, and after a burn. California Public Code PRC 4423 further specifies that permit requirements can vary between counties, so tailor your burn plan to meet the specific expectations of your jurisdiction. Although written burn plans are not always required, it is best practice to write down and follow the basic elements of a burn plan before ignitions of any planned burn. A well-developed plan not only ensures thorough preparation and safety but also documents your due diligence as a responsible landowner. Additionally, a burn plan is required to take advantage of the gross negligence standard affordfed by SB332 (2021 Dodd) and the Prescribed Fire Claims Fund, with some exceptions for cultural practitioners. Once you develop your burn plan and identify your weather prescription, you can look for **burn windows**, or specific periods (hours, days, weeks) when weather, fuel moisture, and environmental conditions allow for controlled, predictable fire behavior that align with your management objectives.

By developing a prescription and establishing a defined burn window, you can ensure the burn meets management objectives, minimize risks of escape or unintended impacts, and closely monitor forecasts as the target season or date approaches. Monitoring the weather within the burn unit can help you understand microsite conditions, daily weather patterns and can help develop your prescription. Monitoring can also mitigate the potential of having to cancel or postpone your burn at the last minute.

Developing Your Prescription

Broadcast burn prescriptions consider several weather parameters. You need to identify weather ranges for each weather parameter that are expected to meet burn objectives. Weather ranges will vary based on location, crew experience or resource availability, fuel type, and burn objectives. For examples of burn plans and associated prescriptions, visit California's Prescribed Burn Association website (https://calpba.org/). Common weather parameters that often influence fire behavior (Table 1) include:

Temperature: changes in air temperature influence fire behavior. Consider both your burn objectives and vegetation/fuel type to determine the appropriate minimum and maximum air temperatures for your prescription.

Fuel moisture content: the percent water content of your fuel (e.g., live or dead vegetation) when compared with the dry weight of that material. Targets for fuel moisture ranges vary by vegetation/fuel type, desired burn intensity, and management objectives.

Weather Parameter	Influences on Fire Behavior
Temperature	High temperatures contribute to increased fire behavior by drying and preheating fuels.
Fuel moisture content	Impacted by environmental conditions and structure of materials to burn, fuel moisture greatly influences fire behavior. Fuel Moisture can be calculated using charts from the NWCG *Fire Behavior Field Reference Guide* (PMS 437).
Atmospheric stability	During unstable conditions, fire behavior increases, and smoke dispersion improves, while stable conditions limit vertical motion and therefore suppress smoke dispersion and decrease fire behavior. During stable conditions, warmer air can trap cooler air close to the ground, called an **inversion**. Smoke can be trapped close to the ground during inversion conditions.
Probability of ignition (PIG)	High PIG values indicate that fuels are highly receptive to ignition. Conversely, low PIG values suggest that fuels are less likely to ignite, which may result in the fire not carrying well through the intended burn area.
Relative humidity (RH)	High RH generally reduces fire behavior while lower RH values typically increase fire behavior.
Seasonality	High temperatures and low fuel moisture in the summer often make it unsafe to burn. Conversely, low temperatures and high fuel moisture in the winter can inhibit burning altogether.
Wind direction and speed	Winds directly influence fire spread by accelerating the warming and drying of fuels. Light winds can help move fire in your desired direction and dissipate rising heat, which can reduce damage to trees. High winds further increase a fire's rate of spread and flame length. Consistent wind speeds and direction allow fire practitioners to predict fire movement. Additionally, topographic features such as canyons, gorges, saddles, or ravines create avenues for wind to funnel through.

Table 1: List of common weather parameters and how they can influence fire behavior.

Atmospheric stability: is the tendency for the vertical motion of air. When conducting a broadcast burn, slightly unstable conditions are often considered favorable, as it helps lift smoke and has steady winds. However, greater instability causes wind gusts and turbulence, which can lead to unpredictable fire behavior. Atmospheric conditions also change depending on time of day (Figure 1). You may be able to burn during stable conditions, but because smoke-sensitive areas could be negatively affected, you should work closely with your local air district staff.

Probability of ignition (PIG): the likelihood (expressed as a percentage) that a firebrand (i.e., ember or spark) will cause igition when it lands in receptive fuel beds. PIG is influenced and calculated by factors like temperature, relative humidity, and fuel moisture content. It is a useful measure, as it is a single value that takes many weather parameters into consideration. Probability of Ignition and the weather parameters it takes into account can be calculated using charts from the NWCG *Fire Behavior Field Assessment Guide* (PMS 437).

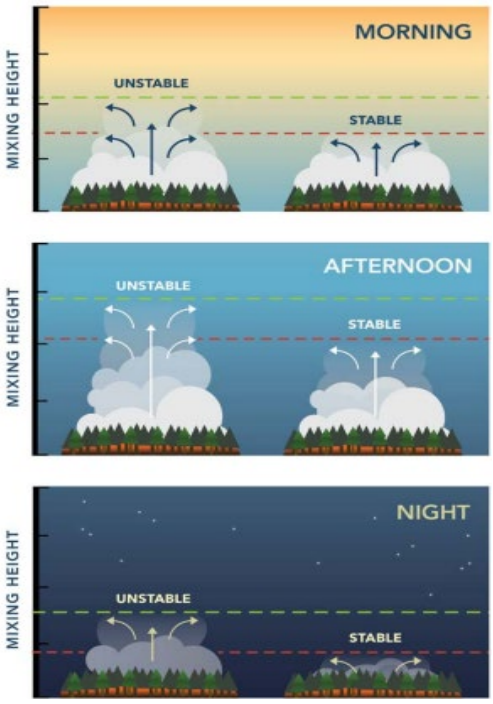

Figure 1: Stable and unstable atmospheric conditions at different times of day and the corresponding changes in mixing height. Diagram credit: Jessica Shaklee.

Relative humidity (RH): the ratio of the amount of water vapor evaporated into the air compared with the maxmium amount possible at that temperature; typically expressed as a percentage. RH ranges required for combustion will vary by vegetation/fuel type. RH typically has a diurnal effect, opposite of temperature: as temperature increases during the day, RH values drop, and then RH slowly increases with cooling temperatures (Figure 2).

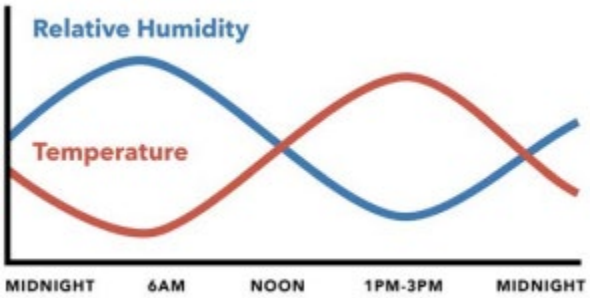

Figure 2: The relationship between relative humidity values and temperature changes throughout the day and night. *Credit: Guidebook for Prescribed Burning*

Seasonality: refers to the recurring changes in weather patterns that occur at different times of the year. In California, fire practitioners often conduct broadcast burns in the spring or fall when weather conditions are moderate. Seasonality may also refer to phases of plant growth and development, and some burn objectives (e.g., invasive species control) will require specific timing that favors and/or disadvantages target species. Knowing your desired management objectives and weather conditions will help you determine when to burn.

Wind direction and speed: wind direction is expressed as the direction it is coming from, while wind speed is how fast the wind is moving expressed in miles per hour. Consider topographic features during your burn planning and be wary of burning on days with highly variable winds forecasted, even if the wind intensity is within your burn prescription. When identifying an optimal burn window, remember to take into account that conditions in your burn unit may differ from local weather predictions. Even a short duration gust of wind outside your prescription can lead to containment issues. Take caution if you are observing wind gusts in your weather forecast outside of your prescription.

When developing a weather prescription, it is strongly advised to work with someone that has burn experience to develop specific weather ranges. It is also advised to tie varying levels of crew/resource requirements listed in your burn plan to “cool”, “target”, and “hot” burn day conditions based on your prescription.

Finding a Burn Window

Finding a burn window involves monitoring weather patterns weeks to days before your burn to ensure there are predictable and consistent weather conditions that match your burn plan. Local knowledge and an on-site Kestrel or Weather Station can help confirm real-time conditions. Additional resources to assist with finding an adequate burn window include:

The **Fire Environment Mapping System (FEMS**; https://fems.fs2c.usda.gov/ui) is an interactive user interface with maps, tables, and charts that display Remote Area Weather Stations (RAWS) data. This website includes archived observations from each RAWS to track weather patterns as well as a 7-day hourly forecast of weather.

The **MesoWest** website (https://mesowest.utah.edu/cgi-bin/droman/mesomap.cgi?state=CA&rawsflag=3) allows you to compare observed forecasts near your burn location (from nearby weather stations, including government- and privately-funded stations) with the day’s hourly weather forecast. You can focus the map to your burn area and manually select the specific weather parameters (e.g., temperature, wind, humidity) you would like to compare and see how the weather models are performing compared with what is actually happening on the ground days before your burn.

The **National Weather Service (NWS)** website (https://www.weather.gov/fire/) provides 7-10-day weather forecasts and seasonal outlooks. NWS provides fire weather planning forecasts for specific locations that include forecasts for windspeed, relative humidity, temperature, and more.

1. For local information, first enter the ZIP Code for your burn location.
2. Use the mapping function to zoom-in and click on the map for the location of your burn.
3. Scroll and select the "Hourly Weather Forecast" option (below the aforementioned map) and you will see a graphical representation of how the weather is forecasted to change hourly. This is useful when paired with MesoWest forecasts days before a burn to see if there are any consistent discrepencies between what is forecasted and what is actually observed on those weather stations.
4. Within ~48 hours of the burn, it is also helpful to view the "Forecast Discussion" page for your location to read NWS staff's interpretations of projected conditions. This is where they discuss their level of confidence, or lack thereof, in the forecast that the weather models have generated.

The **Northern California Geographic Area Coordination Center** (**ONCC;** https://gacc.nifc.gov/oncc/predictive/weather/index.htm) and **Southern California Geographic Area Coordination Center** (**OSCC**; https://gacc.nifc.gov/oscc/predictive/weather/index.htm) provides a 7-day outlook for fire potential, a smoke forecast, and a fire weather webcast that is updated daily.

The **Prescribed Fire Information Reporting System (PFIRS**; https://ssl.arb.ca.gov/pfirs/index.php) is a tool developed by the California Air Resources Board (CARB) for individuals to view prescribed fire activity both locally and statewide. Both agencies and individuals can report activities using this tool. PFIRS also provides an outlook on the likelihood of permissive burn days three days in advance. This is very helpful in planning so you do not have to cancel a burn last minute due to a non-permissive burn day.

Remote Area Weather Stations (RAWS; https://raws.dri.edu/index.html) are a network of strategically placed weather stations across the U.S. that provide reports of key weather parameters including temperature, wind speed, relative humidity, and, importantly, fuel moisture content. RAWS data can be used to monitor weather trends over time because each station contains several years' worth of archived weather data. You can use this resource to assess historical weather conditions for your region to determine a time of year when conditions may line-up to meet your prescriptions, and to better understand fuel moisture conditions in relation to current weather. If your burn unit is not located near a RAWS, the data may not provide accurate forecasts.

What is a permissive burn day?

The California Air Resources Board specifies each day of the year as a permissive, marginal, or no burn day for each air basin or specified area.

A **permissive burn day** is when broadcast burning will not significantly degrade regional air quality and the local air district approves of burning consistent with local smoke management guidelines and programs.

A **marginal burn day** is when limited amounts of broadcast burning for individual projects in specified areas will not significantly degrade regional air quality and burning is authorized by the air district consistent with smoke management guidelines.

A **no burn day** is when no broadcast burning is allowed due to the likelihood of creating adverse smoke impacts or exacerbating existing air pollution. Exemptions are possible; contact your air district for details.

The **Weather Underground** website (https://www.wunderground.com/) provides local and long-range weather forecasts, weather reports, maps, and current weather conditions for your given location.

The **Windy** mobile app and website (https://windy.app/map/) provides a detailed weather forecast and live wind map. Some features are free and others are subscription-based. First, navigate to the location of your burn, then view the "Forecast for This Location" section. Depending on your subscription level, you can use the "Compare" option to view up to six different weather models. By comparing forecasts, you can gauge your confidence in wind forecasts for your burn.

Figure 3: Belt weather kit
PC: cascadefire.com

Walking around your proposed burn unit days in advance of your intended burn day is recommended as you can gather site-specific information about on-site weather, such as wind patterns throughout the day or on differing slopes. Documenting onsite weather data using a handheld weather instrument, such as a Belt Weather Kit (Figure 3) or a Kestrel (Figure 4), is helpful if you can access those tools, but is not necessary.

Figure 4: Kestrel weather meter
PC: kestrelinstruments.com

Additional Considerations

During the burn, use tools to ensure the weather parameters are within your prescription. You can use many of the aforementioned resources to develop a burn window, however, using handheld tools such as a Kestrel or Belt Weather Kit allow you to immediately obtain weather conditions for your site. Tracking weather patterns during your burn is a crucial task to ensure you stay within your prescription throughout the entire burn. These tools can be purchased online or potentially borrowed from your local Prescribed Burn Association (https://calpba.org/) or cooperative extension office. Be sure to keep records of your weather readings throughout your burn event, as these will be useful documents to show due diligence if a problem occurs. It is common practice to take and record weather prior to ignitions, then hourly during the burn event, and again at the conclusion of the burn. Monitoring during the burn can help identify wind shifts, temperature spikes, or RH levels dipping.

After the burn, continue to monitor the weather until all hotspots and smoke have subsided. It is important to continue using weather tracking resources during this time to ensure safe containment. When observing weather patterns after the burn, be sure to watch out for high wind events, significant wind shifts, low relative humidity, or higher than expected temperatures, as these could increase the risk of re-ignition in the burn unit. In units with heavy fuels, stumps, or dirty piles with potential for long-term smoldering, monitoring may be needed for weeks (and sometimes months) after the burn, especially in the spring when conditions are progressively drying.

Weather is only one component of prescribed fire, but it is the single most important factor in planning broadcast burns. As you establish your burn prescription and burn window, approach the process with both mindfulness and practicality, and consider reaching out to your local PBA, RCD, Fire Safe Council, fire department, or CALFIRE unit for technical assistance.

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Learn more about the UC ANR Fire Network by visiting our webpage at https://ucanr.edu/sites/fire/