Weather and Fuel Monitoring for Prescribed Burns

PART I: FUEL STICK MONITORING

Set Up

What is a Fuel Stick

When planning a prescribed burn understanding the conditions in the burn unit is important to deciding when to burn, to ensure you are within your prescription and will achieve the desired objectives. The dead and live fuels are one main component which determine fire behavior, and should be considered in your burn planning and monitoring.

Live fuel moisture will be different from dead fuel moisture and will vary significantly with season and species. Live fuel moisture can be measured by weighing and drying live fuel samples, but this is not generally necessary. Dead fuel moisture content is easier to obtain and more relevant for prescribed burning as dead fuels will be the primary carrier of many prescribed fires, particularly of lower intensity.

Fuel sticks are a tool for better understanding the moisture content of small dead fuels and how fuels on your site adapt to atmospheric conditions. The 10-hr fuel stick is only representative for certain fuel types. The 10-hr fuel stick is mainly applicable for timber understory or forest structure burning, with a range of size classes included in surface fuels. It will not be as applicable for grass burning because it will not be as representative of the fuel size class that will be carrying the fire, but can still demonstrate trends and site responses to atmospheric changes.

Time Lag Fuel Classes

The time lag fuel classes are a method of distinguishing between different size forest debris and fire carriers, from grasses to logs. Fine fuels generally refers to small diameter, flashy fuels which will dry quickly and burn quickly due to high surface area, such as grasses and conifer needle litter. Heavy fuels or coarse woody debris refers to larger diameter material such as logs, downed trees, and large limbs. In addition to these qualitative descriptors used to describe fuels on the land, there are quantitative descriptors such as time lag classes which enable consistent measurements and comparison of sites. These classes are used in most forest management protocols for measuring fuel loading on sites.

1-hour: 0 to 0.25 inch diameter
10-hour: 0.25 to 1 inch diameter
100-hour: 1 to 3 inches diameter
1000-hour: 3 to 8 inches diameter
10000-hour: greater than 8 inches diameter

For monitoring fuel conditions for prescribed burning, the 1-, 10-, and 100-hr fuels are most commonly monitored. Probes exist for measuring moisture content of 100- and 1000-hr fuels and calculations can be made to approximate 1-hour moisture content. One of the most commonly applied options for prescribed fire monitoring is simulating a 10-hr fuel in the environment and measuring its moisture content simply through weight changes. A 10-hr fuel stick is a set of manufactured rods, each 0.5 inches in diameter, that has a bone-dry weight of 100 grams. The weight of this rod above 100 grams thus directly represents its moisture content, with no calculations required. There are other tools and methods for measuring and determining moisture of other time lag classes, but the 10-hr stick is broadly useful and accessible.

Where

When deciding where to set up the 10-hr stick, select a representative area that as closely as possible resembles the area you are hoping to burn (in terms of canopy/shading, fuel height, fuel type, etc.). If you are burning a more larger or heterogenous area multiple fuel sticks may be necessary.

The standard is to place them on metal wire stands 8 inches off the ground. However, it may be best to adjust the height of the stands to represent the average fuel height. For example, if your main fuels are surface fuels in contact with the ground (needle and leaf litter) lower down or even placed on the ground may make more sense. If you have a masticated fuel bed, small shrubs, or more fuels higher off the ground the elevated stands will give a more accurate representation of your fuels. When setting up, avoid touching the fuel stick or putting it anywhere but on the plastic it comes in or on the stands.

When

Once a general burn window is identified, have the fuel sticks out a few weeks in advance in order to give them time to adapt to the conditions. They should be brought inside if it rains heavily or snows to keep them in good condition.

Over three time-lag periods a fuel stick will become 90% adjusted to surrounding conditions. In reality, because atmospheric conditions are always changing the fuel stick moisture content will be constantly fluctuating as well. What this means is smaller time lag classes (smaller diameter fuels) adjust to atmospheric conditions faster and will fluctuate more throughout the day.

Measuring Fuel Sticks

How to Measure

It is best to take readings of the fuel stick at a representative time of when you expect to be burning – likely sometime between 9 AM and 1 PM. Taking readings at approximately the same

time every time you check the sticks will be most helpful for gaining an understanding of site conditions and comparison to forecasts. If possible, taking multiple readings throughout the day can be helpful to get an idea of daily trends and to determine the daily ignitions window. To understand weekly trends and how on-site weather and conditions compares to the forecast, taking readings every other day or every few days for a few weeks can provide significant insight.

To measure the fuel stick you will need a precise and accurate scale which can measure to within the nearest gram with accuracy and precision. A small spring scale is generally standard because they are highly accurate and easy to use in the field, but a precise kitchen or household scale can work as well. When checking the fuel stick, do your best to avoid touching the stick itself. Any oils, dirt, or moisture transferred to the stick can change its base weight and make readings inaccurate. The top metal hook can be used for picking up or moving, as well as to attach the spring scale clip to. Record the reading and location, date, and time it was taken. The weight of the stick above 100 grams represents its moisture content. A weight of 113 grams for example, translates to 13% moisture content for 10-hr fuels.

What This Tells You

The fuel moisture on a given day can vary across sites depending on altitude, aspect, slope, canopy cover, surrounding vegetation and fuel structure, and other factors. This is why for a large or more varied unit setting up multiple fuel sticks is valuable. Unfortunately, there are no firm rules regarding what moisture content is ideal for burning. It depends highly on the season, fuel type and structure, other weather conditions, and the objectives of the burn. The 10-hr sticks are helping you to determine the impact of different weather conditions on the fuels themselves.

It can be helpful to think of the weather and fuel factors as sliding scales which all relate to one another. A higher temperature can allow for effective burning with higher fuel moistures or higher relative humidity. Alternatively, if the temperature and humidity are on the cooler, wetter end of the prescription, a lower fuel moisture may allow for more effective burning and better consumption. The fuel moisture is just one of many factors and it must be considered in concert with many others.

It will take some time to determine what fuel moisture levels translates to good burn conditions for different seasons and different objectives on your own property. Broadly, a general range within which burns are often conducted is 7 to 17% moisture content, but a test fire and conducting burns in a range of conditions is the best way to determine where in that range you should be for your property and objectives. It is also important to remember that the moisture of 1- and 10-hour fuels will vary slightly throughout the day and burn window as conditions fluctuate.

PART II: WEATHER MONITORING

When and Why to Use a Kestrel Drop

The Kestrel Drop is one option for remote on-site weather logging. While you cannot remotely access, the device measures temperature (dry bulb), relative humidity, and dew point and logs readings at a selected increment. Data can then be downloaded whenever convenient. It can also conveniently be connected to any phone with the Kestrel app, thus allowing data to be downloaded by multiple people/phones.

An on-site monitor such as this is helpful leading up to a prescribed burn to better understand how conditions within the actual burn unit compare to the local forecast or any nearby weather stations. Varying aspect, slope, and canopy cover can significantly alter micro-site weather conditions within given atmospheric trends. If a property has varying fuel types/structures and aspects, utilizing a weather sensor in different locations can be helpful in understanding variations in fuel and weather conditions on the property, and when windows for different units may be available. When selecting a location for the Drop, make sure the fuel cover and shading is representative of the rest of the unit, and that it is not in a draw or exposed area which will have more extreme conditions.

Using the Drop for On-Site Monitoring

Set Up

1) Set up of a new Kestrel: Remove from box, open rear battery door, and remove plastic pull tab.
2) Download Kestrel LiNK App from app store.
3) Open app and press black button on Drop. The app automatically opens to the Devices tab, and the device should appear. Tap connect and the Kestrel Drop is now linked.
4) Select Dashboard to see current conditions and start recording, or select Settings to name the Drop and see other information. To change the log settings select Manage Device Data, where you can change the sync rate of live readings and the log rate of recorded readings. Recording readings every 10 to 30 minutes should be adequately frequent and will extend the battery longevity.
5) Select representative site for placement of the Drop. Easiest and often makes sense to place near a fuel stick so you can check both at once.
6) Hang Drop from a tree or vegetation in representative shading of the rest of the unit.
7) The Drop is automatically recording, just check that it has adequate battery life remaining.

Monitoring

1) Get within Bluetooth range of Kestrel Drop monitor (about fifty feet). Ensure Bluetooth is enabled on your phone.
2) Open Kestrel app, and navigate to History tab at the bottom. Then select Timeline at the top and select the Device Log file.
3) Within that page, by toggling to Stats you can see statistics and plots of the logged data. You can also export the data to maintain an external log using the top right upwards arrow button. The text file which exports is a csv file which can easily be converted into a spreadsheet. You can email, text, or air drop it to yourself or others for further analysis.
4) If you would like to record at a higher sync rate temporarily, from the device Dashboard you can select Start Recording and the device will record readings at the Data Sync Rate (preset to 5 seconds) rather than the Data Logging Rate (preset to 10 minutes). This is not necessary for most recording purposes – the Kestrel will automatically be on and recording as long as the battery lasts.

PART III: WHAT THIS DATA MEANS

Why Monitor

The weather and fuels trends over time and the course of a day can be very helpful for multiple reasons, including:

- Understanding daily and seasonal cycle weather cycles on your property.
- Understanding how local weather station data compares to your site conditions. Especially if you have limited on site monitoring capability, once you have an understanding of trends and how forecasts translate to conditions on your property, less monitoring may be necessary.

Many NOAA and RAWS weather stations have 10-hr fuel sticks at them and share the readings online. If there is one at a location near a burn unit the readings from that station can be translated to your burn site if you are able to measure a fuel stick and compare the trends. Weather sites are often somewhat exposed and may be drier and warmer, so it is important to calibrate any readings or forecasts to your actual site conditions, but often local trends will still be accurate and helpful.

Collecting fuels and weather data leading up to and during a burn is critical to conducting safe and effective burns. Knowing the conditions you are burning in and the fire behavior it translates to is critical to increasing your capacity for intentional fire. Taking notes throughout the day of the burn on weather and fire behavior will build your knowledge base on ideal burning conditions on your property for meeting different objectives.

Finding Local Weather and Fuel Stick Data

Find Closest Weather Station (Mesowest)

1) Visit Mesowest site.

2) Select California for region and NWS and RAWS for Network.
3) Zoom into your area to see all nearby stations.
    - Change Display Overlay to see current station readings of temperature, humidity, or other conditions. Compare the station readings to site conditions to determine which best represents your site.
    - Click on the black dot next to each station to view more readings and see more station information such as elevation.
    - You can also view past readings and download data to compare weather events and trends across stations.
4) To view forecasts for that station google search "NOAA" followed by the name of the station on Mesowest. Select the National Weather Service link (should be the first result) to view forecasts and recent history for that station.

NWS and NOAA Site

1) Find the closest weather station, either by following the steps above, or by visiting the National Weather Service site and searching your zip code or town in the search bar in top left.
2) The hourly forecast is useful for recording and visualizing the forecast.
3) The 3-day history provides actual readings from the station which are helpful for comparison to your property readings. Certain stations have 10-hr fuel stick probes, and the fuel stick moisture content readings will be listed on this history page.
4) If you scroll down to the Additional Forecasts and Information section, the forecast discussion provides more information and an extended forecast.

PART IV: RESOURCES

Link to purchase fuel sticks.
Link to highly accurate field spring scale (300g x 2g option).
Link to purchase Kestrel Drop weather monitor.
Reach out to your local Prescribed Burn Association or Cooperative Extension office about borrowing fuel sticks and sensors and other resources.