Campbell
Prediction
System
Rx

CPS Applied to

Prescription (Rx) Burns

By Doug Campbell

Introduction

Many veteran fire technicians rely heavily upon "intuition" to accomplish prescription-burning operations. But the intuition of experienced personnel is not a good teaching mechanism. In order to progress we need to discover and describe the knowledge contained in the intuition of the experienced fire officer.

We can't teach others what the outcome of putting a torch to the land will be, without being more specific about the cause and effects of the variations in fire behavior. We can't do many prescribed burns without having some costly and dangerous failures. One prescribed burn that escaped near Corona California destroyed some homes and the owners are seeking compensation. The Lowden Ranch prescribed burn of July 2,1999 escaped near Redding California destroying 23 homes. The Buchanan prescribed burn ran over a crew putting 16 in their shelters and killing one firefighter. If these events were truly unpredictable then that is one thing but they weren't. There are people that know and perceive the dangers but are unable to communicate effectively enough to avert the situations.

Planning and carrying out an RX burn operation is quite complex. Improving our ability to identify the caused of fire behavior variables can add assurance that what is *planned* will be *accomplished.*

CPS incorporates valuable evaluation methods that many fire officers rely upon; their basis for that prized "intuition." Along with this technical information and some practical applications for it, CPS presents a language to communicate this intuitive knowledge.

In' tu i tion
1a. Revelation by insight or innate knowledge:
2a. Immediate apprehension or cognition.

The CPS is unique in that it brings together knowledge on several subjects and presents this information as it relates to the fire fighters and planners. In the following text you'll see how proven techniques are especially helpful when planning and performing the common prescription burn. This new resource is critical to those who have a job to do. I, for one, wish this information was available for the prescribed burns for which I was responsible many years ago.

ABOUT THE AUTHOR

Doug Campbell is currently a Fire Behavior Analyst with the Ventura County Fire Protection District. He is retired from the U.S. Forest Service after a 28-year career managing wild land fires. Doug's unique approach to predicting fire behavior was so popular with the fire professionals that he wrote and published a book and a training course about practical fire behavior prediction in 1991. Campbell's book titled *The Campbell Prediction System (CPS)* is based on his years of experience conducting prescribed fires and his assignments as a fire behavior analyst on forest fires. Doug offers a course addressing the practical methods of wild fire prediction on a contract basis. The Ventura County Fire Department is among a growing number of organizations that use the CPS for initial attack tactics and prescribed fire projects.

THE

CAMPBELL PREDICTION SYSTEM APPLIED TO PRESCRIPTIVE BURNING

C.P.S was developed by recognized fire behavior analyst Doug Campbell in 1989, and implemented by the Ventura County Fire Protection District in 1992. The Campbell Prediction System or CPS, is a method of fire behavior prediction that is practical and simple. This system is designed to be used to manage fire intensities using a combination of logic, specific information relating to variations and their cause and the use of a special language to communicate with others. The CPS has replaced the old method of one person making a tactical decision and directing the firing and holding crews without them understanding the reasoning behind the orders. Now the entire team can and does make predictions of the variables and understands the reasons behind the directions given during the operations.

Ventura County Fire Protection District is currently relying on the CPS to select and test the tactics for wild land fires and prescribed burns. This has been the testing ground for using CPS on prescribed fires.

The objective of CPS is to predict the time and location of variations in fire intensity. Predictions allow firefighters to be mentally ahead of the situation and to adjust tactics before the fire changes. The prediction allows the selection of tactics that will use those variations to a winning advantage. Refining into a special language the intuition of highly experienced firefighters developed methodology for this system. Many of those veteran fire fighters knew fire behavior, but could not say *how* they knew. This situation is the result of trial and error from on the job training. CPS teaches how the experienced wild fire officer predicted fire behavior changes, and adds a language to communicate the knowledge. By doing so, CPS put into a training program much of the information learned by field experience enabling trainees to learn the art of prescribed burning much quicker and with less errors in the processes.

CHAPTER 1

After the burn plan is approved there is much preparation and evaluation needed to assure a successful completion of the project. The following will take you through our thinking and planning to illustrate the processes the Wildland Fire Officer of Ventura County Fire Department has tested and adopted after some 20 projects were completed.

Using a Fire Intensity Window

To base the firing tactics on the fire behavior model is not logical. By that I mean that the model will not represent all the variables of fire behavior. The variables that occur cause the problems and on the other hand, are the answer to better accomplishment. There is much latitude given to the Firing Supervisor because of the need for the officers experience, in order to be successful. The experienced RX burn officer uses information gained from experience. This experience has taught the officer to be able to predict the outcome of putting the torch to the fuel. This experience has taught how to manage fire intensities so that the fire will burn hot enough to consume the desired amount of fuel and not escape control. Sometimes the difference between success and failure is a very fine line.

This skill has not been taught in school but rather limited to on the ground exposure. These, on the ground training opportunities, are extremely limited. Until one obtains experience one has not had an opportunity to learn the skills of managing fire intensities. It is important that a way is devised to enable the necessary skills to be taught as other skills are, in training classes. New information not contained in the burn plan is needed as well as procedures to take after the burn is determined a GO.
CPS/Rx is the way to start identifying the new information and procedures that will advance the art of prescribed burning.

Improving the Burn Plan

Although the fire model describes the computed fire potential there remains a need to identify when and where the variations in the fire intensities will occur during the course of the burning operation. When fire variations are predicted and utilized in the tactical approach the operation will be successful. Therefore it is important to understand what causes these fire behavior variations and how to use the knowledge to accomplish error free prescribed burns. The information that is needed is not yet a part of the prescriptive burn plan but resides in the minds of the few experienced fire officers.

After the checklist is complete the final step to approving the start of the burn depends upon the area being within the RX *window* and remaining there. Contained within the RX *window* as it is called, are the elements of weather and the fuel. The acceptable range of the air temperature, humidity, fuel moisture live and dead, wind direction and speed comprise the elements in the prescriptive window. It is required that the values measured on site must be within this window in order to start the burn.

Close attention is paid to the weather; continuous readings are taken at various locations to assure the site remains within the RX window. If the conditions change and the values go out the window it is required the burn be stopped or a waver is granted to continue. If the fire escapes or fizzles and the burn managers have complied with the rules then the agency usually finds no fault with the personnel conducting the burn. It is the variation that causes the problems and the fire behavior model does not do an adequate job of describing the variations. This policy presumes that the variations within the approved RX window are not predictable. The use of CPS will add the variation predictions to the requirements prior to conducting the burn.
Since 1993 there have been some refinements that have helped to assure the successful completion of the prescribed burns in Ventura County. These are:

- Perimeter assessment planning.
- The firing sequence and timing plan.
- The Test burn analysis.
- Using fuel temperature variation as part of the Rx window.
- The Intensity prescription.
- The Escape Analysis.
- The use of shaded terrain maps and Solid Terrain Models.

- The Video Burn Logs.

The Perimeter Assessment

Where the perimeter of the primary boundaries of the burn are located follow these principles.
The exposure is "Out of Alignment" with slope or timing or wind.

This makes the exposure less vulnerable to fires spread. When it is not possible to do so on a section of perimeter then some mitigating measures are planned. The times that fire has crossed the primary line we have been able to pre-determine the size and scope of the expansion. The Boundary II burn was one such example. The area most at risk was noted on the map 2 years prior to the event of the escape. There is a video record of this event that has been used often for training.

The Firing Plan

How is the burning to be managed? The firing plan is written and a part of the burn plan document. How is the firing sequence and timing plan developed? Does the prescriptive window play a part or not? Does the BEHAVE fire model help determine the firing plan? What standard approach is recommended, or is there one at all? How is the firing plan evaluated? Who evaluates it? Will it work or fail? These questions are what the Operations people need to answer. If you are required to be responsible for prescribed burning you need to have answers to all the above questions.

The CPX/RX attempts to describe the elements of a firing plan in detail. Let's start with identifying some additional information that is crucial to the success of any burning project. We will isolate information that is useful for fire behavior variation predictions. To be successful the firing plan must account for variations that change the fire intensity that could cause the burn to fizzle or cause it to suddenly race out of control. A competent fire officer should be able to determine the variance information is displayed and noted on the firing plan. The firing plan should show cause and affect which is the predictive information needed to assure the achievement of success. The question to answer is: "Does the firing plan include information and tactics that describe how the fire intensity will be managed?"

Each segment of the burn should have a custom firing tactic designed to utilize the special features of the area to enable managing the fire intensity to optimal levels within the normal variations of fire behavior at that specific point in the RX window.

The test burn is analyzed to determine the variation in intensities. This is the fire's signature. This signature is the information that is used to determine how to manage a variety of intensities and consumption's. A training video has been made using these opportunities.

From this scene the fire is proclaimed a go or no-go.

What Do We Want to Accomplish?

Each burn plan has a stated consumption objective. This objective calls for a percent of dead and live consumption reducing the fuel for whatever benefits are desired.

How is the consumption objective assured? The fire behavior model describes the mid point within a range of variation. This information is a *fire danger* description but not a *fire behavior* description. The average flame length and consumption is not usable information to determine how to create hotter or cooler fire. What information is it that will help us determine the variations of fire intensity and the consumption before we light the fire? We want to accomplish the ability to manage the intensity of the fire. We obviously need to use information that will be specific to the cause of fire behavior variations occurring while the weather is constant. What is apparent is that the fuel flammability is a variable under stable conditions. How can we use that knowledge?

Time and Aspect Considerations

This knowledge of the peak periods of flammability can be used to set the timing of the ignitions for prescribed burns. The question to ask is, do you want the fuel to burn hotter or cooler than the model indicates it would? Do you want the fire intensity to be going up the curve or down the curve? How long will the fire burn with the intensity which will accomplish the consumption objective, where on the flammability curve will it began to burn to the objective and where will it not? Each aspect and time period must be considered as a variable in the potential intensity of the fire. If you want to be able to manage to a particular intensity during the burn than this information is what is needed. Each different aspect and time of burning will produce a variation in fire intensity and fuel consumption. Identify the intensity desired for each aspect and plan the time of firing according to the fuel flammability curve. You can show in the firing plan how to adjust the intensities to meet the demands of various archeological and botanical interests. These concerned people need to know and see evidence that the fire will not be loose and can be managed. Teaching is much quicker than experience.

Smoke Changes Fuel Flammability

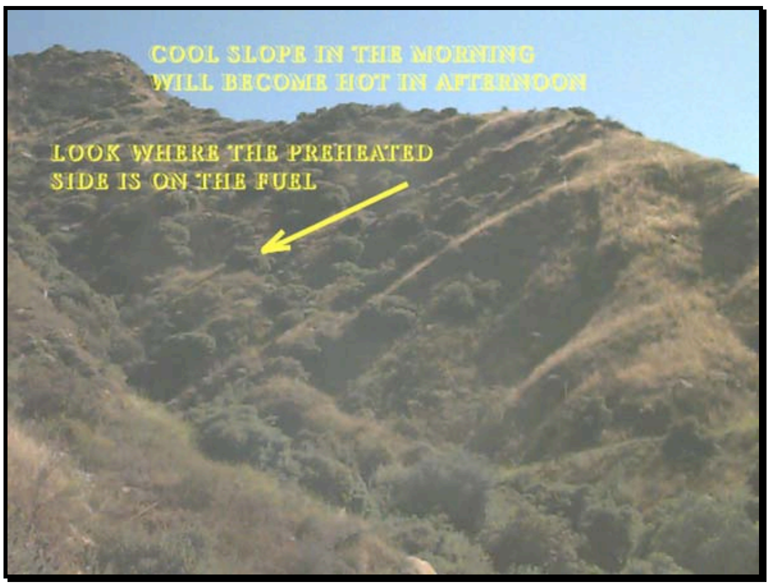
Intensity variations are determined by how much sunlight is getting through the smoke to the fuel. Shading the fuel will change the intensity of the fire. Wind direction and the direction of burning are relationships that are important and need consideration. If you wish to dampen the intensity you can put smoke over the fuel, lowering the solar preheat factor and thereby the fuel flammability. If you wish to keep the fuel as preheated as possible, at it's highest flammability, then you need to keep smoke from shading the fuels.

Fuel Flammability Variation in Single Plants

There are subtle variations that require close observation and attention. Each type of fuel except the very fine fuels such as grass, cause shade within the individual plant. Some fuels have little shading ability because of their porosity. Some with broad leaves or denser foliage shade themselves and parts of adjacent plants as well. There is a big difference in how much shade there is in a plant, as you'll see if you compare a Sumac to a Chemise plant. The Sumac has a broad leaf and it creates a higher percent of shaded fuel within the plant. Each type plant has a different shading characteristic.

Thinking of fuel type as a stable element which burns with even intensity from plant to plant and on variations of the topography are dangerous in the fire profession. Determining the fire intensity from the normal descriptors of fuel is not useful to predict the variations that normally occur. Fuel type, arrangement, porosity, continuity, live and dead moisture content, etc., etc. are data required to produce fire model fodder. The conclusion leaves out the fuels range of flammability variation.

Learning to utilize fire behavior information to enable prediction of the level of variation of fire intensity is not as complex as you might imagine. The question to ask is "where is the fuel in its flammability curve?" When that question is answered, predictions are possible. Each fuel type has a different hot/cool quotient because of its structure. This quotient determines how much of the fuel can be preheated by solar energy. The more shade the plant can produce the greater the affect of the relationship of the heated fuel to the fire is.



If the fire is being carried by grass then as long as the sun is on the fuel the fuel is hot, there is no cool side to grass. If the fire is burning in brush or timber there is a hot and cool side in relation to the direction the fire enters the fuel. Fire burning into the hot side of the plant will burn hotter, consume more fuel and move on faster than when fire burns into the cool side of the plants.

This alignment of the fire and the flammable side of the plant will be a factor in how the fire behaves. If you need to reduce the heat then light so the fire is not burning into the hot side of the plant. If you want to heat it up then fire the area so the fire enters the hot side of the plant. The firing supervisor should consider this tactic as another method to manage the intensity to a particular flame length that is most beneficial to the objectives for the fuel consumption.

The language to communicate what you want is simple. To heat up the fire, direct the firing crew to " set fire in better alignment to the hot side of the bush". To slow the fire, say, "Run the fire out of preheat alignment more." It helps the burners to tell them how much flame you want to generate. Say, "Give me 15 feet of flame". Avoid being vague in giving intensity directions; give them the desired flame lengths they are to accomplish.

The Firing Timing and Sequence

To develop improved timing and sequence of firing plans, the time, location and values of flammability variations need to be known. The temperature difference can be measured between shaded and sunlit fuels. Variations in fuel temperature are determined by the use of a temperature instrument that has two leads and will register surface temperatures. These instruments are readily available on the commercial market. The instrument reveals the temperature difference between sunlit and shaded fuels. Test fires will quickly identify the fuel temperature required to assure continued combustion. Even though the area is within the RX window, the fuel may not burn until its temperature has reached a certain point. That information is important to have before commencing the burning.

The burn may fizzle in shaded fuel of a temperature of 70 degrees while at the same instant the fire will run and spot in hot fuel of a temperature 120 degrees. Normal temperature spread between hot and cool fuel while within prescriptive windows is 30 to 60 degrees Fahrenheit. Management of fire intensities is done using the knowledge of where and when there exist fuel temperature differences. When you want the maximum intensity light off hot fuel.

The peak flammability period of various aspects can be identified and measured. Each aspect should have a time of optimal burning assigned it to assure flammability variations are predicted.

Should we be using calculations and fire modeling or test burns to determine the timing and sequence of burning? Picking the point on the flammability curve to start burning is crucial to success. Testing for the truth by use of a test burn is absolutely necessary to the process. The test burn evaluation will reveal the reality of the burning situation and get you off on the right foot. When the evaluation is complete, the time allowed for burning the various aspects will also be known. This is what establishes the timing, of the firing and burnout operation.

The Sexton Rx burn done in October 12, 1995 was a case where the weather began in the morning with the air temperature and humidity below the window limits. Air temperature was in the high 50's and the humidity was measured at 79% that was below the Rx window.
At 0930 the sky was clearing and the temperature rose to 65 degrees and the humidity lowered to 66% and hung there for the rest of the day. The east aspect was selected for the test fire and a thirty-minute period was given the fuels to heat from solar radiation. The fuel temperature reached 120 degrees even though the air temperature and the humidity remained out of the Rx window. The test burn was lit and was declared a go for the burn. The cool fuel on the south and west aspects was 66 degrees, the differential was 54 degrees. The firing sequence and timing were to burn using fire aligned with the hottest slopes, following the sun around. Beginning with east aspects then south then west the burn went as planned. A video burn log was made of the entire sequence of events and is on file in the Wildland Fire Officers office.

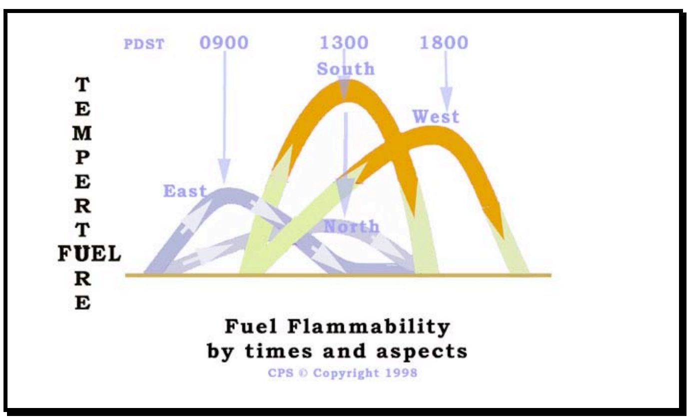
How Fire Danger Affects Fuel Temperature

There is a distinct relationship between fire danger and variations in fuel temperature. At moderate fire danger, when the air is 80 degrees and the relative humidity is 40%, the range of fuel temperature might span only 30 degrees. During extreme fire danger of 105-degree air temperature and

10% relative humidity, the fuel temperature spread might be 70 or even 80 degrees.

The difference that fuel temperature variations cause in fire behavior can be quantified by observing fire intensity differences in hot and cold fuels that are on fire. These signatures are useable for predicting fire intensity during the burn. Test fires are the best method to establish these variations of fire intensity.

Our method considers the aspect and time as *critical elements* in the test. Performing a test burn without knowing whether it is hot fuel or cold fuel provides inadequate information. Such a burn would not reveal sufficient information to gage the variables in fire intensity.
Most the test burns should be ignited when the fuel is at its peak flammability. This will reveal the maximum intensity potential of the fire burning under the current weather. A handy pocket card that depicts the generic fuel flammability curves for the 4 slope aspects.



The flammability card is a quick reference to use for prescribed and wild fire tactics planning. To ascertain if the fire behavior will be diminishing or accelerating, look at the flammability curve for your aspect. If that point on the curve is not yet at its peak, expect accelerating fire intensity. This can be communicated as "***going up the curve.***" The maximum fire potential intensity can be turned as ***"at the peak of the curve."*** If the time indicates that the peak has occurred, we can say that the aspect is ***"going down the curve,"*** and that the potential flammability is diminishing with time.

If different fuel temperatures are causing significant intensity variations, follow these steps:

1. If the aspect is not already on fire, locate the area on the card by aspect and time.

2. Observe and note a place in the burning fire that is representative of the aspect of concern.

3. This observed fire intensity reflects the potential intensity on the subject aspect.

Some prescribed burns have escaped because the test burn was evaluated when the fuels were below peak flammability. Such fires can easily escape because the maximum potential intensity remains unknown and lesser intensities were predicted.

When firing the perimeter of the project, plan to fire these areas when the exposure is low on the flammability curve. Fire escapes are more easily controlled when they occur in COOL fuel. Burn the perimeter when the fuel inside the area is HOT and the exposure fuel is COOL.

Another tool can help to visualize the relationship of aspect, time and fuel flammability difference. This tool is comprised of a contour map and a highlighting pen.

Remember: Smoke shades fuel and temporarily affects the fuel flammability.

The Fuel Flammability Map and its use

Campbell uses a fuel flammability map to identify the variations of fuel flammability for prescribed burns and wild fires. Terming the highlighting device a Yellowommeter, he highlights the hot aspects in either the morning or for the afternoon hours. This fuel flammability map makes it possible to communicate and visualize the times that fuel on the various aspects are potentially more flammable. In the afternoon from about noon to 5 o'clock, the colored areas are the western, flats and southern aspects. A morning map hot slope map would highlight the eastern aspects.

These Yellowommetered maps are now standard procedure for the Ventura County Fire Department. The timing of ignition is planned by considering the fuel flammability variations, in and adjacent to the burn area. The Yellowommeter map is also used as a tactic planning aid on wild fire incidents. This flammability map is an excellent visual aid that helps determine timing of certain tactics.

CHAPTER 2

THE ALIGNMENT OF FORCES CONCEPT

Three major forces heavily influence variations in speed and intensity of wildland fires: **wind, slope and the preheating of fuels.** These potent forces can work in cooperation or against each other.

Forces that complement each other (producing a cumulative effect) are said to be ***"in alignment."*** When forces are not aligned, and are below their maximum potential to aid the spread or intensity of the fire, the forces are then ***"out of alignment."***

> The alignment of forces can alter the spread and intensity of the fire

At the HEAD of the fire, the forces are most aligned with the direction of the spread of the fire. The HEEL of the fire is the point where the forces are in direct opposition to the spread of the fire. The FLANKS of a fire can be identified as the point(s) where the fire spread is working at 90 degrees of the force alignment.

By observing specific parts of a fire and understanding the alignments of the forces, it is possible to develop a foundation for predicting fire behavior change. Through reading the forces and their alignments on the topography, you learn to predict the resulting fire intensity and the potential change as force alignment evolves.

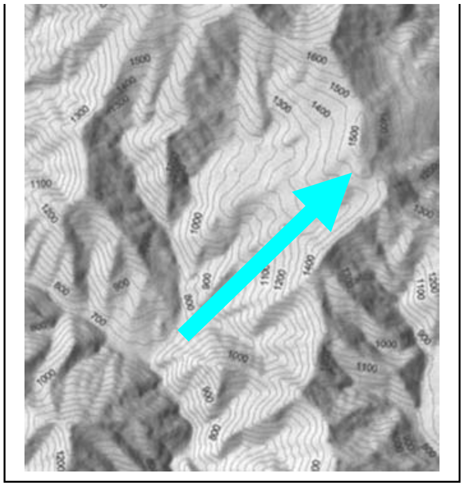
Consider a fire that is free burning and is spreading equally in all directions from the point of ignition. If no outside force is applied to give the fire a major direction, the burn will be round. Apply wind force to the situation and the fire will take a direction and shape caused by the wind.

Another potent force that affects the speed and intensity of the fire is that of slope. A slope in the terrain will “pull” the fire up slope, and retard the spread down slope. If the wind is applying its force in the same direction as the slope, these forces can be said to be “in alignment” with a fire potential that exceeds the potential of either single force without the influence of the other.

Preheated fuels are the third important factor or force to consider. The flammability of preheated fuels influences the speed and intensity of the fire. The hotter the fuel from solar preheating, the greater its influence to affect the fire in the direction of the hot side of the fuel. The time and aspect play an important part in this event but is not the entire story of the alignment of preheated fuel in the path of the fire. In medium brush and timber fuel one side of the plant is hot and the other is cool. The direction the fire enters the plant in alignment with the heated side is important to the amount of fuel consumed and how intense the fire becomes. There are preheat variations caused by aspect and time differences in the path of the fire and by the heated side of the plant and its relationship to the direction the fire burns into it. There are two alignments of preheat to consider.

To determine the comparative change in the rate of spread and intensity of a fire, compare the alignment of forces currently influencing the fire with the alignment of forces in the fires path. The more nearly aligned are wind, slope and preheated fuels, the greater is the potential spread, intensity and consumption of the fire in the direction of this alignment of forces.

These observations and the language used to describe the potential fire behaviors are the mechanisms to predict and communicate fire intensity



changes. Knowledgeable predictions can be easily expressed in a manner that includes the basis for the prediction.

EXAMPLES:

"The steep slope ahead of the fire will add considerably to the slope force, and the spread will increase after the fire establishes itself on that slope."

"The forces of slope and wind are in better alignment for the fire at the base of that hill. The fire behavior intensity and spread will increase when the fire gets to that point on the topography."

"When the fire burns over the top of the ridge, the slope will be out of alignment and the fuels are colder, so the fire will slow at that point."

" The wind change that is forecast will change the alignment of forces on the South exposure. When that happens, the fire will be in better /alignment."

Observations of alignment of forces acting upon the fire are the baseline that can be used to predict how the fire will react on the topography around the fire. Learn to envision the reason for the HEAD, HEEL and FLANKS of a fire in this way. It's easy for experienced fire officers to visualize the differences in the alignment of forces on various places on the topography. Identifying places where there is greater or less alignment of forces can greatly aid in accurately predicting changes in fire behavior.

Armed with the knowledge of how these forces affect a fire's behavior, it is possible to manage fire behavior and to create the intensity desired. Conduct a test burn to distinguish the range of fire behavior variation that differing alignments create while within the prescriptive window. Identify the alignment combinations that create the desired intensity. Guided by this knowledge, place the fire on the ground when and where the alignment of forces are known to produce the desired intensity. Avoid torching fuel when and where the area is outside the *fire intensity* RX window. Set fires at specific alignments for specific results.

About Wind and Smoke

Wind direction is significant because wind is a force that will push fire and its resulting smoke, right along with it. Flames bending down wind and the smoke billowing over the terrain are both relevant since they can have an effect on a fire's intensity. Smoke blocks solar radiation and will lower the flammability of hot fuels. It stands to reason then, that maximum fire intensities can be maintained by positioning lines of fire so that the smoke does not shade the fuels in front of the flames.
Fire can be ignited so that the intensities can be at maximum or retarded by the variations in the alignment of wind and smoke.

Use of strip head firing, (firing strips ahead of the flames) so that the fire runs in alignment with the wind and up slope) will produce maximum flame length.

To lessen fire intensity, turn the firing down slope. This produces a strip of fire that is not in full alignment with the forces of slope and wind, thus reducing intensities.

Shading Fuels with Smoke

In order to suppress intensity, string fire so that smoke shades the fuels in front of the flames. This condition lowers the flammability of the fuels that are next to be consumed and reduces the consumption of the live fuel. The fire intensity is lessened due to lower solar preheating. With significant smoke cover, actual fuel temperatures can be lowered 30 degrees or more. However, fuel shaded by smoke for only short periods is not affected sufficiently to reduce the temperature of the fuel or decrease its flammability. Fuels that have been heated are dried and reducing the temperature will not increase its moisture content.

When fuels preceding a fire are shaded, the full ranges of intensities that can be produced are narrowed because it is not possible to attain the hottest intensity. But this situation may sometimes be desirable to create. The principle thing to remember is that smoke is a “side effect” of fire; use it to your advantage when needed. Some controlled burns were ignited and burned well until the effect of the smoke shaded the fuel, lowered its flammability, and snuffed out the fire.

Attaining Fuel Consumption Objectives

By experimenting with the introduction of fire upon topography, it is possible to attain the desired flame lengths and appropriate consumption required by the prescription objectives. This is the purpose of a test burn.

As an example, a fire's highest intensity was 25-foot flame lengths created while in full alignment. Observations of the fuel consumption determined 95% of the live fuels and 100% of the dead fuels were burned. Positioning fire to burn at 90 degrees of alignment with slope and wind produced 10-foot flame lengths, consumed 80% of the live fuels and 100% of the dead fuel.

The prescription called for 90% of the live fuel to be consumed. Therefore it is reasonable that with the same conditions as the test fire, that flame lengths between 10 and 25 feet can be managed to. To accomplish the consumption objectives, the firing supervisor needs to manage the variable to produce 15-foot flame lengths.

> Keep it simple:
> ask the firing team
> to light fire in a manner
> to produce 15 foot flames.

The prescription called for 90% of the live fuel to be consumed. Therefore it is reasonable that under the same conditions the test fire burned, that flame lengths between 25 feet and 10 feet are desired.

To meet the burn objectives, the firing supervisor needs to manage the intensities for 15-foot flame lengths.

Planning Aids

The C.P.S. method uses photographs and topography maps that depict timing and sequence of firing. The planning team delineates the planned perimeter for the prescribed burn on a topography map. The VNC mapping unit is an important aid to planning.
The normal wind for the season is depicted upon the map by drawing wind arrows. The intolerable wind velocity and direction are identified and noted.

Planning Needed in the Future.

With the assistance of a local meteorologist Campbell plans to identify and describe weather patterns that are that are desirable for individual projects. Since there are synoptic weather patterns that are especially beneficial, and others that should be avoided, it is appropriate that each burn project be reviewed for best - and worst - case weather patterns. This knowledge and some planning alongside local forecasters will help avoid undesirable weather systems and changes while burning. We have found that fuel temperature variation due to solar preheating is muted in mid winter months often producing only 15 to 20 degrees elevation from shaded fuels.

The interchange with weather specialists also helps when planning burn projects. Certain months are renown for producing specific weather conditions, like the winds of March or September's Santa Ana winds.

Firing the Perimeter

Often, it is wise to widen control lines by burning before igniting the interior. This is a separate operation and should be considered separate from the interior firing even if the two operations are done on the same day. Time the sequence of fire so that the perimeter lines are burned first. Be sure to consider the alignment of forces on exposures before firing the line.

The scheduled time for firing the perimeter should be set so that there is a differential of fuel flammability or alignment of forces between the fuels to be burned and the exposures to be protected. This method has been used to successfully on burns even without the use of fire lines to contain the fire. Fuels that are low on the flammability curve create a favorable situation for the holding crews. Any fire that becomes established beyond the lines will occur in COLD fuels.

Timing Ignitions by the Position on the Fuel Flammability Curve

Do not ignore timing, it is critical when planning a burn. Be aware of how time will affect the fire behavior. Prescribed fire plans and wildfire tactical plans should have a *"timing window."* When delays widen the window, it becomes out of synchronization with the desirable flammability relationship, and things go wrong. Both perimeter and interior firings should have a timetable established.

Too Low on the Flammability Curve

If a fire is planned when the fuel is too far down the flammability curve, the entire operation can bog down. At some point on the curve, firing will fail to carry, and no amount of torching will overcome the depressed flammability condition. When a fire tells you it won't burn, believe it! In such an operations you're firing beyond the time that should have been the cut off time. If the fuel flammability curve is not adequate to sustain the burn, fuel and effort are wasted and the areas must be re-fired when the fuel is higher on the flammability curve. Thus it is important to choose wisely the fuel's position on the flammability curve when timing the firing. Timing is a critical element.

Too High on the Flammability Curve.

When exposures are threatened by spotfires, the burning operation should cease before the exposure fuels are too high on the flammability curve. When a given exposure is increasing in flammability-- or coming up the curve-- slop over and spot fires easily develop into escape situations. This is a timing error.

If a spot fire occurs in exposure fuels when the fuel flammability is increasing, *getting worse*, should you continue the firing operation? No, "***the tactic has run out of time.***"

As exposure fuels become more flammable, the fire behavior will get worse. More spots will occur and intensities will increase. If the fire behavior is near the threshold of control and the firing operation is continued, the fire will escape.

Timing for Intensity Management

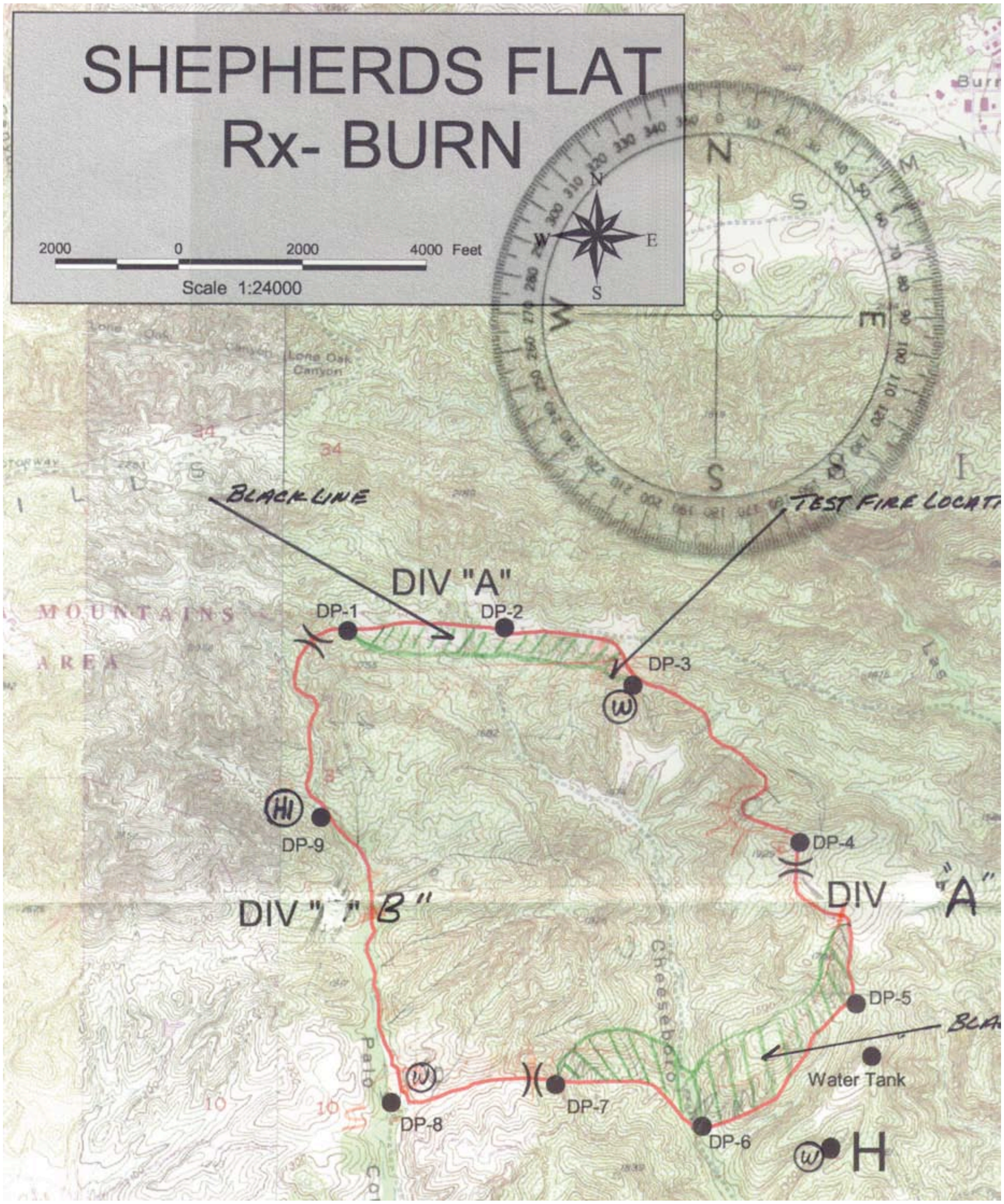
Timing is very important to consider when managing fire intensities. Selection of the appropriate alignment of forces and the start and stop points on the fuel flammability curve, are keys to intensity management. Most burns are time sensitive. Get behind the time line and you loose the ability to manage the fire intensity to the optimal extent.

Firing plans should include the timing as well as the sequence of firing. The timing of the operation can be described in narrative form and on maps or photos of the area. All involved in the burn project should know the timing plan.

As an example, planning the timing for a burn that has two primary aspects, east and west the timing would be as follows.

At 8:00 a.m. the teams start firing the perimeter of the east aspect of the project. This ignites the east aspect at its highest flammability. Firing east aspects on the cooling side of the curve will result in the fire intensity being depressed. Afternoon firing of east aspects is liable to cause the fire to fizzle and no amount of fuel or fanning will overcome the lack of sufficient preheat.

For the west aspect, the burning is scheduled for afternoon. This aspect is the driest and has been receiving solar radiation all day long. The timing window can be set for *off the peak hours* to dampen intensities if it is desirable to do so. Thusly the timing and sequence plan is formulated.



An afternoon hot slope map is prepared and the wind force displayed over the topography. An oblique photo taken in the afternoon will have the hot slopes sunlit and cool slopes shaded doing the work exactly. Adding the wind forecast on top gives a realistic display of the alignment of forces that the plan can be built around. Upon the map, start points and time intervals are placed. The division assignment sheet refers to the points on the map when describing where the crews start work and finish.

CHAPTER 3

Using Observations to Predict Fire Behavior Change

The Campbell Prediction System used for prescribed fire planning, focuses upon the major forces that cause the variations in fire behavior. These are the differences or changes of:

- Wind direction and velocity
- Fuel flammability variations (caused by solar energy variables over time and terrain in the fuel bed)
- Slope variations
- Alignments of the above forces over the topography

What is the percentage of hot to cool fuel in the fiel bed?

Understanding how to recognize these differences and observing their relationships is a great aid in predicting fire behavior.

A variation in surface fuel temperature is easy to see on the topography. The aspect nearest to perpendicular with the sun is experiencing peak solar heating. These areas are the hottest, most flammable places at that time.

When shadows grow shorter, fuel temperature and flammability is becoming higher. Shadows growing longer over time are evidence that the fuel flammability is diminishing.

Observations of fire burning in both HOT and COOL fuels at the same time reveal to an observer the range of fire behavior is that is caused by the flammability difference in the fuels.
Given that other factors are about equal, the range is the difference in the flame lengths between the two areas.

The Campbell Prediction System makes use of the CPS fuel Flammability Card to serve as a reminder and quick reference of the timing of the peak flammability's and to determine if the aspects are increasing or diminishing in fuel flammability.

> Consider this:
> The differences in fuels self shading ability,
> Grass = 5%, Oak brush 60%
> Oak is more sensitive to the position of the shade relative to the fire than grass or chemise brush is.

The procedures for quantifying the fire intensity variations due to fuel flammability differences are as follows:

Measurements of the variation of fuel temperatures are taken and recorded. These measurements are taken at the start of the test burn and at the time of peak flammability of each selected aspect. The information gleaned is then added to the weather readings to quantify the degree of fuel temperature variation under the current fire danger condition. Air temperature, relative humidity, wind speed and direction, fuel stick and live fuel moisture readings are also recorded.

Test fires are set to determine the degree of variation of intensity. The flame lengths and fuel consumption associations are then recorded.
As noted earlier, it is easy to see the effects of different fuel temperatures by observing the differences in flame lengths between HOT and COLD fuels.

The flame length is associated to the consumption and the logical conclusion is that certain flame lengths produce a certain percent of consumption.
When you identify the flame length that produces the consumption objective the optimal flame length to manage to have been identified.

Note how the flame entered the plant. There will be a difference in the consumption determined by alignment of preheated side and the entry of the flames. Fire entering the plant in alignment with the hot side will consume more fuel. Fire entering the plant out of alignment with the heated side will subside and consume less fuel.

Fires set at various alignments to the forces of wind and slopes are needed. Three primary alignments will create three intensities. From one ignition of a spot set on a slope, fire will burn in full alignment, at 90 degrees of alignment and 180 degrees out of alignment. These are the HEAD, FLANKS and HEEL of the fire.

Under a no wind condition, the HEAD of the fire would be the portion of the fire running up slope, the FLANKS would be the portions of the fire moving across the slope at 90 degrees to the slope, and the HEEL of the fire would be that part that was backing down slope. Record the flame lengths of head, flank and backing fire segments of the test burn.

Record The Test Fire on Video

Because the variations of alignments and the resultant intensity variations it is important to record the event in a visual way. Using a computer program that allows the addition of graphics, we produce a video record of the fire danger values and the measurements of the variables. The video, records the results that could replace the fire model in depicting how fire reacts to sets of conditions. The video records the variations and in so doing, you can see for yourself the truth of how the fuel burned. The next time re is a plan to burn similar sites, the video record can serve to re-establish the fire teams reference and expectations.

Record the Results of Various Intensities on Fuel Consumption

After the test burn is cool, observe and record the dead and live fuel consumption in each area of different fire intensity. For example, the head burned with 20-foot flame lengths. The dead fuel was 100% consumed and the live fuel 95% consumed. The flanks burned with 10-foot flame lengths and consumed 100% of the dead fuel and 75% of the live fuels. The heel burned with 2-foot flame lengths and

List that information on the VNC test burn form. If the test was conducted at the time the aspect was at peak flammability then you have seen and recorded the maximum flame lengths the fire will produce while under the same fire danger condition.

If you do not know where on the fuel flammability curve the test burn was performed, you are still uneducated about the possible variations in this fire's behavior. If you observed the head of the test burn fire burned with 10 feet of flame lengths and you were unaware where of the fuel flammability curve the test was completed, you would not know the time the HEAD would increase or decrease in intensity.

Test burning for all points on the flammability curve would reveal the maximum variation in fire intensity and consumption of fuels. This procedure would most likely be overkill in real prescribed burning programs, but would produce valuable data for storage and later use.
If it were possible to capture all the information that all the wild land fires have to offer, we could apply it usefully on prescribed fire programs. Perhaps other fire agencies can be encouraged to follow Ventura County's Wildland Fire Officers example.

For instance, a wild fire is burning and you observe the flame lengths of the head, heel and flanks. If you noted the time and aspect (or where on the fuel flammability curve it was burning), the weather and topographic information of percentage slope and fuel classification, you would have a complete fire behavior segment that will repeat under similar conditions.

If the above information was available and a test burn was planned under similar conditions, the information could replace the test burning. Unfortunately, this information is rarely captured. And the result is that we have to start from scratch each time we do a prescribed burn project. In these days of computer technology, we have the capability of capturing, storing and retrieving vast amounts of information.

If agencies are to improve their skill and proficiencies in prescribed burning, then they must start to accumulate, store and review ***fire behavior information.*** We must become knowledgeable of the variations on the fire ground that can be used to assure successful accomplishments of prescribed burns.

We should practice the steps to success, teach how to, plan accordingly, test to reveal the truth, implement, record the event, store the information and review the information before the next burn.

What Information to Use, when and what for

Prescriptive burning windows consist of the highs and lows of many ***fire danger*** elements. The RX window that is information used in calculating the fire intensity using a fire model produces one set of values. The model assumption is that all values remain constant. Two or three sets of conditions are fed into the calculation and produce some variation of intensities. The RX window is adjusted and written into the prescription to be adhered to. This information is necessary to allow torching the land. To do so without this processes would be a negligent act or arson.

Because this information represents the fire but is not sufficient to describe the variations that normally occur, the firing technician must have available more specific information. Up until now this information was contained in the experienced fire officers intuitive sole. Intuition is not a reliable tactical tool. Conducting the firing operation is very different than planning the operation. To know if an officer has the right intuition another with known perfect intuition must evaluate that officer while in the act of working with a fire. This method of training and gaining experience is costly in many ways.

Managing Intensities Information

Replacing intuition with a system and special information is what CPS has attempted to accomplish. The C.P.S. System adds the ***fire behavior*** variations to information required in the prescription. The fire intensity variations observed are the ***reality*** of the situation and can be observed and quantified.

Many Times, The Fire Behavior is OK, but We're Out of the RX Window

On a number of occasions during active projects, the weather readings indicate that the project burn area has climbed out of the fire danger window. The required tactic is to stop burning. In reality, however, the actual fire behavior variations are well below the threshold of control and within the fuel consumption objectives. To continue is not in agreement with laws and policies. There now must be some attempt to ask for a waiver to continue. What reason can be used that will make sense to the administrator who may be in an office downtown?
Many officers have recalculated the fire model and by tweaking the inputs create a correction and ask for a window opening. There must be a better way than that!

How to Continue When Out of the RX Window

If the burn is started while in the RX window why not discontinue its use at that point? Ask for permission to use the new fire intensity window created during the test fire phase of the burn.

The prescribed burn manager can manage the fire behavior intensities_and can give more weight to the fire *behavior* window and less to the theoretical fire *danger* window. The observed fire behavior is the ***real*** situation. The prescriptive window is a guideline and contains theoretical and generalized fire behavior values. Logic implies that reality should replace theory and actual fire should replace the fire model at the point in time fire introduced. Requesting or authorizing the burn to continue needs to be based upon a thorough understanding of the capability of the burn boss and crew to manage to objective intensities under the observed fire conditions even though the hot side of the RX window may be exceeded. Let the real fire have the final say before you throw the project out the RX window. When the burn situation is such that intensities can be managed within the *intensity window*, it is appropriate to request continuation of the project. The request: "The fire intensities are within the intensity objectives and we can manage the intensities under this fire danger condition." Communicating the situation is all that is necessary to enable continuing of the project.

CHAPTER 4

Fire Modeling and CPS/Rx

TASK 1. Prepare a summary of burn objectives for the Incident Commander. These are a part of the prescription.

TASK 2. Prepare the firing sequence and timing for the burn.
The objective is to remove dead and live fuel in the amount specified in the objectives of the burn plan. The firing plan should be written to accomplish the objectives of the prescription.
This is easy to say..... and hard to do.

The authority to ignite the area is conditional: ***The fire danger must be within the specified range and be predicted to remain there for the duration of the burn.***

The Prescriptive Fire Danger Window

The fire danger window is a description of acceptable conditions; fire behavior must be within reasonable boundaries. This specified range of fire danger and behavior elements is called "the prescription window," or "RX window."

Flame lengths and rate of spreads are calculated for high, mid, and low points in the window. The fire behavior model data are derived from combinations of values of weather, topography, fuel type and condition. Eighteen fire behavior entries are required on the fire model input worksheet. Use of the fire behavior model, will describe generalized flame lengths and rate of spreads. Additional input can be made to determine the values for HEAD, FLANKING and BACKING fires. These calculated flame lengths and rates of spread are only computations and not derived from on site conditions. They are not to be taken for data that can replace the need for test fires.

Fire Behavior Modeling and its Use in Prescribed Fire Planning

Utilization of behavior models assures that the burn planners have estimated results of the project by using the latest technology available. The results from this torching the land require predictions prior to approval of the plan. These fire behavior models are the most practical and the best method available to initiate the burn planning.

When to Rely Upon the Fire Modeling

It is necessary to know when to use fire behavior models and when such use is not appropriate. Fire behavior modeling is a good planning tool but does not provide adequate specifics to use for tactical actions.

The limitations of the fire model are explained in a paper written by Richard C. Rothermel titled, 'How to Predict the Spread and Intensity of Forest and Range Fires.' Published in June of 1983, NFES #1573.

> ***"The fire model is primarily intended to describe a flame front advancing steadily in surface fuels within 6 feet of, and contiguous to, the ground"***

Why conduct and evaluate a test burn if the fire behavior modeling can predict the results? Because the prescriptive window is comprised of *fire danger* ingredients and not those things that cause the *fire behavior* differences. The fire behavior model predicts the fire intensity based upon *fire danger* conditions that remain constant over the time frame selected.

The values of weather, slope, aspect and fuel condition in the general area are considered to remain constant during the time of burning. The fire behavior model will produce a constant, single, intensity.
Weather elements consisting of, fuel type, fuel moisture and slope provide inputs for the fire behavior model. The calculations indicate that the fire will burn with 10-foot flame lengths from 10:00 a.m. to 4:00 p.m.

The model inputs do not consider variations in fuel temperature within the fuel bed or how fire enters the fuel. These fuel temperature differences would be 30 to 60 degrees. Uneven surface and fuel temperatures determine the air temperature, relative humidity and 10-hour fuel stick. The fire behavior model uses air temperature taken four feet above the bare ground and fuel stick values representing the generalized fuel flammability. ***This is a fire danger focus. Fuel temperatures are a fire behavior focus.***

Model inputs consider the fuel flammability as a *stable element* for the duration of the time selected. In reality, we know this is not the case. The fuel flammability changes hour by hour. Fuel is not a stable element because its flammability is constantly changing. Fuel on west aspects in the morning, compare very differently from the same fuel flammability in the mid afternoon.

Will the fire produce the flame lengths and consume the predicted amount of dead and live fuels, calculated, by the fire behavior formula? **No, it will not!** This calculation is theoretical and is not the best information to yield the best job of prescribed burning.

Should we make more calculations then? What if we made more calculations for various combinations within the RX window, until all the variables are put into the model?

Visualize the variations in the topography that are in a typical burn project. In order to secure sufficient outputs of the fire behavior model, calculations would be necessary for each 2-hour period, each different aspect, slope, mid flame wind and so on.
Air temperature and relative humidity readings should be recorded at all varying points of the topography.
Even after all that, the theoretical flame length would only be a better estimate. Obviously, this idea is not practical. The fire behavior model has done its job and the burn plan is approved.

Stop relying upon the fire behavior *models* to predict *fire behavior* variations using the *fire danger* ingredients. When the burn plan is signed and approved, the use for fire modeling is over.

Using Test Burn Observations

Next on the agenda is to complete a test burn. Previously, there was little information available on how to evaluate a test burn. CPS/RX uses real time, non theoretical, test fire observations to capturing fire intensity and consumption information. There is no need to compare the test burn intensities to the models outputs. The test burn should be done to gain real evidence of the intensity variations that can occur *within the RX fire danger window.*

Test burns are the optimum method to establish the extremes of fire intensity.

The Test Burn

Test burning is highly recommended before staffing on site and committing the whole area to burn. The purpose of the test is to assure the experienced fire officer that the fire will burn within thresholds of control and with enough heat to remove the prescribed amount of vegetation from the land. What does the officer see during the test burn? How are the evaluations made? Most fire officers simply say the test indicates the fire will carry and “burn OK” or it “will not burn OK.” And on that basis the burn is either initiated or delayed. Other personnel involved may not know the processes the fire officer went through to arrive at the conclusion. CPS/RX has attempted to identify and to put into words, the processes used by some of the experienced fire officers.

Important Information Observations should Capture

Selecting where and when to conduct the test.
In order to obtain the best data the time and the placement of the test burn should be carefully selected. Find a place on the topography that represents areas where you want to know how the fire will burn. If there are many topographic or fuel variations within the burn area, pick one with some of the variations. Select an area where the fire can freely run, flank and back so the variations of fire alignments can be observed.
Time the test burn so that the aspect is at the peak of the flammability period. Obviously, the tests need to be done prior to the day of actual burning unless the project is very small or quite simple.

Before lighting the test burn take a photo of the area to record the before situation. Record the on site weather, time of day, aspect and the hot and cool fuel temperatures as well as the fuel temperature spread. The CPS Test Burn Form is designed for recording written data.

Check to assure that conditions are within prescriptive limits and that holding crews are in place to extinguish the burn on command.

Light the fuel at a single point and allow the fire to spread. Make sure the fire is burning free and is beyond the influence of the other side of the fire before noting the various flame lengths produced at the HEAD, FLANKS and HEEL of the fire. Photograph the burn with a video camera.
When the fire has burned long and far enough to gather this data have the crew extinguish the fire.

This is a good training opportunity for firefighters. Setting up a drill helps others to learn how to evaluate wildland fire and predict variations before attacking the fire. Thus, the training benefit is established and quantified.

Evaluate the information obtained by the test burn. What was the flame length and consumption ratio differences on the HEAD, FLANKS and HEEL of the burn? Compare the objective consumption percentage of dead and live fuel consumed with the actual consumption in the various sections of the test burn. If the test burn did not accomplish the objective with the head, flanks or heel of the fire the fire danger is too high or too low. This information would indicate that a change in the RX window is necessary. If the head fire was the only place that enough consumption was attained, the fuel must be more flammable to make the burn a success.

What we are looking for that will be evidence the fire will accomplish the consumption objective is that the fuel objective has been attained between the head and heel of the fire. This is evidence that the firing supervisor can maintain flame lengths sufficient to accomplish the consumption objective.

There must be sufficient variation to work with. The optimal fuel consumption n the test burn would be at midpoint between HEAD and FLANKS of the burn. This flame length becomes the intensity objective.

As an example: For 75% consumption of the live fuel that is coastal sagebrush, the flames need to be 15 to 20 feet. The firing crew will be given this objective flame length to attain. As the burn progresses, alignments will change over time and topography, causing flame lengths to go out of the objective window. If the firing supervisor wishes to change the intensities and consumption the officer will adjust how fire is placed in the fuel bed. Knowing the cause and affects of fuel flammability and the alignment of forces are crucial to the successful management of intensity.

The Firing Supervisor and the Operations Section Chief need to be able to predict the intensity that will occur as fire is placed in various alignments. This test burn data is the basis for predictions of fire in the project burn area under the prevailing conditions.
It is this data gathered by observations of live fire that enable fire officers to give orders and direct the placement of fire on the land.

How many Test Burns are needed?

Each project is different. Test burning is needed to find the range of fire intensity that will occur while in the RX window and at various points on the fuel flammability curve. Burn to find maximum intensity variations that will occur while in the RX window. The burn supervisor must have enough information to decide when to light and how to lay fire on the ground to safely accomplish the objectives of the burn. This is what should decide how many places need to be tested.
Testing can continue year around combined with fire drills. The fires are not considered test fires unless the CPS burn form is completed and a video record made of the event.

Creating the Firing Plan

The first step is to obtain a contour map and a photo of the burn area.
Label the document as follows:

1. Compass references
2. Name of Burn
3. Overlay the burn perimeter on the map.
   a. Make the perimeter lines along ridges or canyon bottoms.
   b. Avoid lines with no topographic variations on either side.
4. Label the Drop Points, the I.C.P., Helispot, Staging areas etc.
5. Mark and identify Divisions on the map
6. Mark the predicted wind directions on the map do not overlook local transition wind changes.
7. Label the sequence and timing for firing the perimeter.
   a. Starting point, direction and time.
   b. Ending point, and time to complete firing.

This last item will determine the number of firing teams required to meet the schedule.
The timing of ignitions needs to be done for each aspect. Timing can be expressed as clock hours or the segment of the fuel flammability curve. The test burn will establish the timing limits for each aspect.

Timing is more important in areas where heavier fuels will carry the fire. Where grass is the primary fuel the timing should be based on the information gained during the test burn. Generally speaking soon after grass has sun on it is heated and dried and ready to burn until it is shaded. The timing and sequence plan is for brush types and not as important for grass or fine fuel types.

When burning in brush it is entirely a different story. Brush is greatly affected by the time and aspect as well as the relationship of the heat and flammability of the side of the bush the fire enters. If a burn is done in the morning on a West Aspect, the supervisor needs to realize that the fire behavior intensities will increase until mid afternoon. Since RX burns are usually done during conditions of moderate fire danger, timing the burn near the peak of the fuel flammability curve is generally recommended.

Selecting the fuel flammability range and identifying the time each aspect will be ready to burn determine the timing of the burn. The usual time of peak flammability for an aspect lasts about 4 hours. Ignition timing should be planned by aspect, when the aspect and fuel are near peak flammability. The objective of the timing will be to burn the fuels when they are most flammable. At this time the exposure fuels on the opposite aspect will be cool, a preferred situation for easier control of escapes and spotting. Manage the perimeter lines to that escapes and spotting that may occur will be in areas which are *out of alignment* and therefore easier to control fire on.

How to Direct Firing Teams

The pre selected fire alignment can be amended as the supervisor wishes by the use of simple key phrases. For more heat, call for ***"more head fire alignment."*** For less intensity, call for ***"flanking fire or backing fire."*** Then it is necessary only to indicate where the string of fire should be introduced to the ground. Remain mentally ahead of the fire by making comparisons of fire intensity and the alignment of forces.
If the intensities are within the intensity window, and you make a prediction that there is ***more force alignment ahead*** and call for downward fire intensity by placing fire so it will travel in a more ***out of alignment*** direction through the fuel.

Summary

The Recording of the Program

The first attempt to make a visual recording was on the Broom burns. Still photographs were taken of the test burning and the project. This medium is OK for individual viewing but is not readily adaptable to training or briefing larger groups of people.

The next attempt was the video product of the Aliso RX burn. This video was used in review of the accomplishment and to train firefighters. This was the first attempt to show how we evaluate test burns. The video serves to record the event from test burn to completion of the burning. The follow-up was planned to be a video of the consumption results. This unfortunately, due to constraint of the business has not been accomplished as yet. To produce the video a Quick Take digitizing camera was utilized for still photos. These were imported into a Macintosh computer and manipulated by the Persuasion program into a graphic, slide show type visual. This was fit into a chance video taken by the Safety Officer. This is not an attempt to put any graphics studio out of business but the idea is to record data in a convenient way.

Next, we decided to make up a briefing video for the Incident team meeting of the Pala Comado burn. Taking the Quick Take camera to the scene of the planned burn we photographed key areas that would show the fuel and what the start points looked like. This video was used to brief the firing group and was received enthusiastically.

The next was the same type video made to record the Pala Comado burn that had its name changed to the Boundary Rx burn. The firing plan had been altered in the meantime. The boundaries had been changed. The video shows the test burn and records the decision to continue. Fuel temperatures were taken and a new test burn form revision made.

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