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Prescribed Fire

Monitoring and Evaluation Guide

Prepared by: Prescribed Fire and Fire Effects Working Team

PRESCRIBED FIRE

MONITORING AND EVALUATION

GUIDE

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TABLE OF CONTENTS

INTRODUCTION

The purpose of this guide is to assist in the operational monitoring and evaluation of prescribed fires. A common approach to monitoring and evaluation will enable prescribed fire managers and resource specialists in different organizations and areas to share information about prescribed fire results.

The guide emphasizes fuel, weather, fire behavior and vegetation monitoring techniques. It is with these aspects of fire that the prescribed fire manager is most directly concerned. The techniques for monitoring the effects of fire on other resources such as air, water, soil, and wildlife are also discussed. Since these will vary according to the specific management objectives for the fire, the decision of which variables to monitor and which techniques to use are best left up to the resource specialist. Thus, this guide does not specify "how to" techniques, but rather indicates the range of variables which should be considered.

Prescribed fires often are planned and conducted without monitoring of pre-fire, fire, and post-fire variables. Thus, subsequent evaluation of fire results to determine how well objectives were met is not possible. Important information is lost when the role of monitoring and evaluating prescribed fires is ignored.

The statement of measurable, quantitative resource objectives in the prescribed fire plan identifies what variables need to be monitored at appropriate levels of resolution. Not all variables are necessarily required for all fires. For instance, a prescribed fire conducted to increase water production requires monitoring different variables than a fuel reduction burn. The former would require pre- and post-fire flow rates, while the latter might require the measurement of pre- and post-fire fuel quantities. Additionally, the variables to be monitored and the monitoring resolution might vary between a prescribed fire from a planned ignition and a prescribed fire from an unplanned ignition which is meeting management objectives.

Monitoring is the systematic process of collecting and recording fuels, topography, weather, fire behavior, and fire effects data to provide a basis for evaluating and adjusting prescribed fire programs. Evaluation is a process used to examine and appraise the results of prescribed fire through qualitative and quantitative monitoring data. Monitoring and evaluation provide such things as:

1. A measure of how well resource objectives have been met,

2. A basis for improving economic efficiency,

3. Data that allow replication of desired results,

4. Validation of fire behavior outputs,

5. Opportunities to refine prescriptions based on actual experience, and

6. A basis for assessing long-term effects of prescribed fire.

Operational monitoring is not intended to document prescribed fire variables with the frequency or resolution necessary for scientific research. However, it needs to be carefully designed and implemented so that decisions can be based upon its evaluation. If a greater degree of detail is required, a research program should be initiated.

Monitoring and evaluating prescribed fires may be used by various levels within an organization. The prescribed fire manager and the resource specialist would find these procedures helpful in evaluating fire programs, while the prescribed burn boss would use them to conduct the monitoring program of specific burns.

Monitoring data are collected for pre-fire, fire, and post-fire periods. During each period specific information is recorded. To determine the conditions prior to burning, certain variables should be measured. This period can extend from before the prescribed fire is approved until ignition. Monitoring activities normally begin a few days before planned ignition, but might occur simultaneously with the fire for unplanned ignitions.

While the fire is burning, variables concerned with fire behavior, smoke and existing weather conditions are measured. These variables can be monitored until the fire is declared out. Monitoring during this period provides necessary information to determine whether or not the fire remains in prescription and data on variations in fire intensity needed to evaluate post-fire effects.

The final monitoring period extends from the time the fire is out until all the required measurements are taken. These measurements are used to compare pre-fire conditions to those which exist after the fire. Often they are made immediately after the fire is out, but can extend for several months or years afterwards.

MONITORING VARIABLES

Monitoring variables include those related to fire prescriptions, fire behavior, fire effects on resources, and economics. Prescription related variables include fuels, topography, and weather. Fire behavior parameters describe the on-going fire. The effects of fires on resources such as vegetation, atmosphere, water, soil, and wildlife are also monitored. Finally, the costs and benefits involved are monitored to evaluate the economic effectiveness of the program.

Prescription Variables

Fuel

Fuels include living and dead vegetation. Fuel variables are quantified prior to the fire, immediately after the fire, and periodically afterwards. Information about fuels is used to predict fire behavior and to assess the effects of fire on fuels. Fuels can be described by stylized models that generalize specific fuel variables for large areas (Deeming and others 1977, Anderson 1982, Albini 1976). If greater detail is required, fuel quantity and moisture content by size class, fuel distribution and arrangement, and amount and moisture content of live fuels can be collected.

Fuels can vary from location to location on large fires. In this case, fuel variables need to be measured in each location. In addition, fuel measurements should be made in each of the areas where topographic differences affect fire behavior. As a minimum, areas with different fuel models need to be mapped and several monitoring plots established in each area.

Fuel Quantity - The amount of fuel in tons per acre on the ground is measured by size classes. The most frequently used size classes for downed woody fuels are 0"-1/4", 1/4" - 1", 1" - 3", and 3+". The planar intercept method for measuring fuel quantity is described in Brown (1974). Litter and duff depth measurements can be used to determine fuel loadings by using correlations developed for various fuel types (Agee 1973, Ffolliot and others 1968). Another method for determining fuel quantity is the use of photo series that allow comparisons for both natural and activity fuels to be made in the field with photos of known fuel conditions (Maxwell and Ward 1976a, 1976b; Koski and Fischer 1979; Blonski and Schramel 1981). Each method has its merits and weaknesses for specific situations. The planar intercept method provides detailed information about woody fuels at a relatively high cost, but does not assess duff, herbaceous, or shrub fuels. Litter and duff correlations derived in one area may not be applicable to other areas. The photo series is convenient to use to determine general fuel conditions, but requires an experienced eye for interpretation.

Fuel inventories can be established prior to the burn or in advance of a prescribed natural fire and remeasured periodically after burning using the same sampling locations. The prescribed fire plan will specify how much and what kinds of fuel must be removed if fuel reduction is the desired objective. Before and after measurements are needed to determine the effects of fire on fuels.

Fuel Moisture - Fuel moisture content is one of the most important variables affecting fire behavior. While accurate fuel moisture measurements are difficult to obtain, several methods are available. The 10-hour time-lag moisture is measured in the field with fuel moisture sticks. It represents fuels in the 1/4-inch to 1-inch size class. The 1-hour, 100-hour, and 1,000-hour time-lag moisture contents are calculated using the procedures described in Deeming and others (1977), Burgan and others (1977) or Burgan (1979). Instruments such as fuel moisture probes are also available for the measurement of moisture contents of the various size classes (Sackett 1980, Norum and Fischer 1980).

Fuel moisture measurements can be taken at various points within the unit or at weather stations established on site. A series of measurements should be taken one to two weeks prior to a prescribed burn to determine fuel moisture trends. Additional measurements should be made just prior to ignition, and during the fire. This will also aid in refining fire behavior predictions.

Live Fuel - Many fuel models do not have a live fuel component. For those that do it may be important to know the relative quantity of live fuel present and its moisture content. Plots are adequate for herbaceous fuels, while leaves, needles, and twigs can be sampled by selecting random branches. From these measurements, live fuel quantity and the ratio between live and dead fuels can be calculated.

Live fuel moisture content should be determined before burning. Oven-drying (Countryman and Dean 1979) is the standard procedure. If fuels are small the use of portable moisture analyzers is possible (Sackett 1980).

Fuel Distribution and Arrangement - Distribution and arrangement are important fuel variables but are hard to quantify. Horizontal and vertical fuel continuity should be noted before an area burns. Continuous fuels and the presence of fuel "ladders" indicate the potential for fast spreading fires as well as crown fires. The objectives of a prescribed burn might be to break up continuous fuels and to eliminate a vertical layer. Post-fire observations would indicate if these objectives had been met.

Weather

Weather variables are generally measured for a period before the planned ignition date, just prior to ignition, and during the time of burning and following the burn. For fires from unplanned ignitions, weather information is extrapolated from existing weather stations. The purpose of these measurements is to determine when prescription parameters are met or exceeded and to make fire weather forecasts for predicting fire behavior. The variables include dry bulb air temperature, relative humidity, wind speed and direction, state of the weather, and precipitation. These can be measured at a weather shelter located near the fire or with portable equipment such as a belt weather kit. On large fires several locations may be necessary to represent varying conditions on the fire. If fuel sample plots are used, weather measurements will also be needed as the fire passes over them. Procedures for making these measurements are described in Fischer and Hardy (1976).

Dry bulb temperature - Temperature affects relative humidity, fuel moisture, and fuel temperature. It is measured with a thermometer or thermograph.

Relative humidity - Dry bulb temperature and wet bulb temperature are used to determine relative humidity from elevation adjusted charts. A sling psychrometer is generally used for measurement of the two temperatures although direct humidity readings can be made from a hygrothermograph. Recording instruments are particularly useful to determine timing and magnitude of diurnal fluctuations.

Wind speed - Wind speed and direction affect rate of fire spread and intensity. They can be measured 20 feet above the canopy with electronic anemometers and converted to mid-flame height through the use of charts or measured at mid-flame height with an anemometer.

State of the weather - The amount of cloud cover or shading influences fuel moisture as well as air temperature, relative humidity and fuel temperature. Standard numbers are assigned to subjective estimates of the state of the weather. These are described in Deeming and other (1977) and Albini (1976).

Precipitation - The amount, duration, and days since the last precipitation are used in some prescriptions and are monitored prior to a prescribed fire using standard rain gauges. Precipitation measurements including rainfall intensity might continue for some time after burning to determine the combined effects of burning and precipitation on soil or water characteristics.

Topography
Topography influences fire behavior and subsequent effects in several ways. Slope influences rate of spread, and aspect affects fuel temperature, air temperature, relative humidity, and fuel moisture.

Slope - Slope can be determined from topographic maps and with a clinometer or abney in the field. In either case the measurement should be made parallel to the slope.

Aspect - A compass is used to measure aspect in the field. Compass readings should be taken in the downward direction of the slope. Topographic maps can also be used.

Fire Variables

Fire Behavior

Fire behavior measurements are used to characterize a fire and to relate fire effects to burning conditions. Some fire behavior variables are measured as the fire passes over fuel sampling locations while others are measured for the fire as a whole. Procedures for measuring and calculating these variables are described by Rothermel and Deeming (1980). Actual fire behavior should be compared to outputs derived from fire behavior predictions (Andrews and Rothermel 1982, Rothermel 1983, Rothermel and Rinehart 1983).

Rate of spread - The time necessary for a fire front to burn a specified distance or area is called the rate of spread. Lineal rate of spread is usually measured in feet per minute or chains per hour. Areal rate of spread is measured in acres per hour. Rate of spread should be measured as the fire passes over fuel sampling locations.

Flame length - Flame length observations can be used to determine fireline intensity. Fireline intensity has proved to be one of the most useful descriptions of fire behavior since many above ground fire effects can be related to it. Flame length is a good general index to the elusive meaning of fireline intensity and is also a meaningful fire behavior parameter (Albini 1976). Although simple field methods for measuring flame length have not been fully developed, the measurement must in some way quantify the distance between the base of the flame to its average tip (figure 1). Ocular estimates, photographs, and graduated scales are all possible ways to determine flame length. It is important that this measurement be made, especially if no other fire behavior variable is measured.

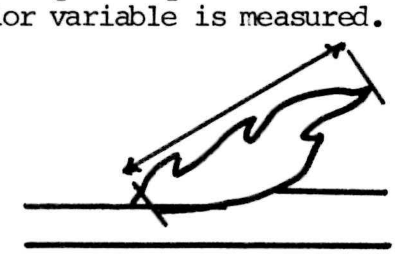

Figure 1.--Flame length measurement.

Crown/scorch height - The height to the base of tree crowns is affected by burning or scorching the lower branches. Scorch height is related to the fire behavior and weather variables and can be predicted from them. It is measured after a sufficient period of time has passed following the fire for the leaves or needles to change color. The percent of total crown which is scorched should also be estimated.

Severe fire behavior - Crowning, spotting, torching, and other severe fire behavior should be monitored and documented on any prescribed fire. These behavior characteristics often indicate that a fire may have exceeded safe burning conditions. Occasional torching or crown fires may be acceptable or desirable to meet management objectives.

Direction of fire spread - The direction that a fire burns is influenced by the ignition method and location in relation to slope and wind. Fires which burn upslope or with the wind are termed head fires while those moving down slope or against the wind are termed back fires. Head fires spread quickly and burn intensely because the flames are in close contact with the fuel, hot air is convected through the unburned fuels, and fires are ignited in front of the actively flaming zone. Under identical fuel, weather, and topographic conditions, a head fire will be more intense than a back fire. Back fires often have a longer residence time and may consume more fuel than head fires (Beaufait 1965). On large prescribed fires, it is important to monitor the direction of burning since slope and wind changes can drastically alter fire behavior.

Effects Variables

The effects of fire on resource variables have been summarized in a series of state-of-the-art reports as a result of the National Fire Effects Workshop. These include fauna (Lyon and others 1978), soil (Wells and others 1979), air (Sandberg and others 1979), water (Tiedemann and others 1979), fuels (Martin and others 1979), and flora (Lotan and others 1981).

Vegetation

Information obtained from monitoring vegetation is one of the key elements necessary to determine how well resource management objectives are being met. Inventories prior to, and following a burn by the use of transects, plots, photo points, or ocular estimates provide a basis for comparisons. Depending on the monitoring objective, sampling may be representative of the entire burn area or just the vegetation assemblages of interest, i.e. range site, habitat type, vegetation type, plant community, aspect, slope, etc. Sampling should continue over a long enough period to establish early successional trends and productivity. Sampling should also be conducted on control plots in order to separate fire effects from other effects. Useful plant data include weight, number, frequency, density, cover, composition, and distribution. The methods described here for vegetation sampling are based on Britton and Clark (1981).

Since fire may burn in a patchy pattern and leave islands of unburned vegetation, care must be exercised with respect to size, number, and location of sample units. Many plants may be killed but not consumed by the fire. Other plants may be alive but weakened enough that they die during the following growing period. Samples for weight, number, frequency, density, cover, and composition should therefore be conducted after one growing season. Spring burns can be sampled the Fall of the same year, while Fall burns should be sampled at the end of the following growing season.

Sampling may have to be conducted in various times of the year to accurately record annuals and perennials and phenological stage.

Follow-up sampling should be conducted after at least one full growing season to show the first year response to burning, and preferably during successive growing seasons since short-term results may have long-term effects. Samples taken prior to burning should be repeated after burning since direct comparisons provide a good evaluative measure for the burn.

Weight - The biomass of vegetation present on a given unit land area is generally expressed on a dry matter basis. For herbaceous vegetation, weight per unit area is used as the basis for determining production, carrying capacity, and fuel loading. Sample plots are clipped at the soil surface from a known area (quadrat), then oven dried or airdried to a constant weight. Samples are then weighed with the final weight being expressed as lb/ac.

Total weight may be broken into its component parts by separating the vegetation into groups (grasses, grasslike plants, forbs, shrubs) or species. It is easier to separate the components prior to drying.

Number - The general ecological term used for expressing the number of individuals is abundance (Brown 1954). Estimates are made for large-scale surveys and actual counts for detailed studies. Rough estimates of abundance are expressed as rare, occasional, frequent, abundant, or very abundant (Brown 1954). Although these broad generalizations may be useful for operational purposes, abundance is better expressed by actual counts in sampling units.

In open grasslands the counting unit is an individual plant or a stalk of a plant. The sampling unit is usually a quadrat measuring 1 yd^2 (Brown 1954). In dense vegetation the sampling unit can be smaller. Quadrats are normally subdivided into smaller parts such as halves or quarters to facilitate counting.

Frequency - The presence or absence in a sampling unit is a measure of dispersion of a plant species. To determine frequency, the presence or absence of a species in a sampling unit is noted. Frequency is expressed as a percentage of the total number of sampling units in which the species occurs.

The number and size of sampling units is important in frequency determination; too small or too few sample units increase the probability of missing important species, while sampling units too large would result in many species having frequencies of 100%. As a rule of thumb, keep plots small so that only one or two of the most frequent plants have a frequency of 100%, but enough plots so that nearly all of the species present are recorded. The number of sampling units may be important since many plants are not randomly distributed, but grow in clumps or patches. Plant species may therefore have a low frequency even though their number and density is high. For this reason frequency should not be the sole measurement used to describe a plant community.

With frequency determinations, a problem of defining what constitutes presence or absence of a species may arise. Herbaceous plants which are greater than 50% rooted within the sample unit are recorded.

Density - The number of stems per unit of area of a species implies the closeness of individuals to one another (NAS-NRC 1962). For trees, each stem on the plot is counted and measured for diameter and/ or height, and then is expressed by size or height class, by species. Density is often used to express proportion of ground area covered by vegetation (NASNRC 1962) and may therefore be confused with cover. The two are not equivalent.

In sampling density, both the individual and the unit area must be defined (USDA - Forest Service 1963). Both fixed plots and variable plot techniques can be used to determine density. The individual is defined as the aerial parts of a single root system. As in determining number and frequency, this may be difficult since root systems are not easily observed. What may appear as a multiple stemmed plant above ground may actually be two or more plants with individual root systems (USDA-Forest Service 1963). Several methods either set arbitrary limits to rooting areas, or set limits to above ground parts regardless of rooting area. These limits are arbitrary and will differ in size between clones of vegetation (Brown 1954). Density is determined by using quadrats or distance measures although quadrat methods are most often used in fire work. Quadrat size should depend on the distribution of the least abundant species (USDA-Forest Service 1963).

Cover - Ground cover can be defined as the proportion of ground covered or occupied by vegetation, rocks, litter, or any other material to be evaluated (USDA - Forest Service 1963). Cover may further be qualified as crown cover, forest cover, ground cover, vegetation cover, range plant cover, foliar cover, etc. Considering the great variation in morphology and class of range plants, it is best to specify basal or crown cover. Herbaceous plants are most often measured by basal cover and woody plants by crown cover.

The crown-diameter method is used for trees and shrubs where the maximum diameter is noted, and a second measurement is taken perpendicular to the first (major and minor axis). The result can be expressed in $ft.^2$, or percent of the total ground area occupied when the number of plants are counted.

Other quantitative methods for estimating cover include the line intercept method, the point method, the step-point method and the Robel method (NAS-NRC 1962, Robel and others 1970).

Photographic techniques provide a visual record of change or lack of change in vegetation cover (NAS-NRC 1962) and are especially useful when used in conjunction with other quantitative methods. More recent advances in photographic techniques developed by Hall (1976) and others, promise more use of photographs in the future.

Composition - Botanical composition is the proportion of a plant species in relation to the total complement of species on a given area. Alteration of composition is often an objective of prescribed burning. Quantitative or relative species composition is most often determined by and expressed as number, frequency, density, basal area, cover, or weight (SRM 1974). When appropriate, photographic and remote sensing techniques may aid in evaluation of the burn. A commonly used technique for determining composition that is well adapted to short, dense, herbaceous vegetation is the point sampling method.

Distribution - The spatial distribution of the vegetation can be described in terms such as dispersed, clumped, aggregated or random. Distribution describes the continuity of the vegetation and affects rate of spread, intensity, and possible crowning. Qualitative estimates of distribution are considered adequate.

Atmosphere

Prescribed fires should not violate national or local air quality standards. To prevent significant air quality deterioration in smoke sensitive areas, smoke management programs should monitor atmospheric variables. These variables include smoke plume trajectory and dispersion and visibility (Mobley and others 1976). During the fire, they should be monitored to determine if air quality objectives are being met.

Plume trajectory and dispersion - Plume trajectory and dispersion must be measured to prevent serious smoke intrusions into smoke sensitive areas. Even though new research is required to adequately model plume trajectory and smoke dispersion, ocular observations of these important variables can be made on the ground of from aircraft.

Visibility - Visibility should be considered in regard to public safety and sensitive recreation areas. Methods to determine visibility include observations, photographs, and various technical instruments such as telephotometers and nehphelometers. Since this is a complex and expanding field, the prescribed fire manager should contact experts from state and federal agencies working in the air quality field.

Water

Hydrologic processes that may be affected by prescribed fire include interception, evapotranspiration, infiltration, soil moisture storage, snow accumulation, snow melt, overland flow, surface erosion, and mass erosion. Management objectives determine if these effects are desirable or undersirable. The quality and quantity of the water resource are related to natural factors (climate, geology, soils, and vegetation) and land use activities (timber management, road building, grazing, recreation, fire management, and mining). Designing a water resource monitoring program requires an understanding of the factors influencing hydrologic processes. In the case of prescribed fire the monitoring system must isolate the effects of prescribed fire from other activities (grazing, timber harvest, etc.) if the objective is to determine cause-and-effect. To obtain useful information from water resource monitoring, the sampling network for collection of data must be properly located in both time and space (Ponce 1980). In some cases it may be more useful to monitor indicators of water resource problems (cover, channel stability, stream shade, infiltration, etc.).

When the decision is made to monitor the effects of prescribed fire on water resources, a detailed water resource monitoring plan should be developed by water resource specialists (Ponce 1980).

Soil

Fire has the potential for altering the chemical, biological, physical, and hydrological properties of soil. Since soil effects are not easily predicted by fire behavior models, careful monitoring data could be used to refine predictive capabilities. Important variables to monitor include soil exposure, temperature, moisture, and chemistry.

Soil exposure - The amount of mineral soil exposed by a complete reduction in fuel and duff depth is very important for predicting erosion potential, infiltration, and plant germination. Ocular estimates of exposed soil are often used, although duff depth measurements give a more quantitative picture. Transect measurements utilizing large nails or spikes serve as a useful technique for duff reduction measurements. This process is discussed in Beaufait, Hardy and Fischer (1977).

Soil temperature - Measurements of soil heating at the surface may be taken before, during, and after burning. The maximum temperature and a continuous record of temperatures are the two most common measurements made. Continuous measurements may be made with recording pyrometers at various depths.

Temperature-sensitive compounds can be installed at various soil depths to provide ranges of maximum temperatures. These commercially available devices are relatively inexpensive and simple to use.

Soil moisture - In some vegetation types, soil moisture is an important prescription variable. Soil moisture should be monitored for a period prior to ignition to determine if the conditions are in prescription. Soil moisture can be measured with several techniques such as neutron probes, tensiometers, oven drying and moisture meters.

Soil chemistry - Although beyond the scope of most prescribed fires, soil chemistry can be important for specific management objectives. Organic matter, mineralizable nitrogen, nutrients and reaction pH are measured from soils sampled before and after the fire. Sample depths of zero to six inches are useful for correlating mineralizable nitrogen.

Wildlife

Prescribed burning to manage wildlife habitat is a process of regulating and rejuvenating plant communities. Impacts on wildlife can be monitored through the use of population censusing techniques and by monitoring changes in vegetation which tend to attract or discourage key wildlife species. Specific vegetation measurements relating to wildlife include species composition, cover/forage ratio, amount of edge, snags per acre, nutrient and protein content, moisture content, quantity and availability (Nudds 1977, Giles 1969).

Economics

The comparison of costs to benefits is one measure of the success or failure of a prescribed fire project. Cost records should be kept for all phases of the project. As a minimum, sufficient data should be collected to determine if the project was accomplished within cost objectives. Records are normally kept of salaries, equipment and supplies. This includes costs incurred during the planning, preparation, ignition, holding, mop-up, control and monitoring phases. An economic analysis should also consider the risk and cost of excapes and the costs involved in preparing to burn even though ignition is delayed or postponed due to being out of prescription. If the benefits from a fire are to be considered on a long-term basis, costs should also be prorated over that time period. Cost data should be stratified according to objectives of burn, season of burn, size of unit, fuel type, ignition method, elevation and aspect to evaluate which factors contribute to increased or reduced costs. Benefits are normally identified in the resource management objectives for the project. Benefits may be tangible or intangible but both are measurable if the resource objectives are specific.

MONITORING VARIABLE TABLE

The monitoring variable table (Table 1) summarizes the variables to be measured, their priority and the time period for their measurement. Variables indicated by an "x" are considered essential depending on the objectives of the fire. Priority Level 1 variables are essential for all fires and represent the minimum recommended requirement. These variables are necessary to decide when to burn, quantify fire behavior, and record monetary costs and benefits. Variables at priority Level 2 are those that would be desirable to record. While not essential, these variables provide additional information about prescriptions and behavior.

Table 1. PRESCRIBED FIRE MONITORING VARIABLES

Monitoring Variable	Management Period Pre-Fire	Fire	Post-Fire
Prescription Variables			
1. Fuel Quantity	1	-	x
2. Fuel Moisture	1	2	-
3. Live Fuel	1	-	x
4. Fuel Distribution	2	-	x
5. Dry Bulb Temperature	1	1	-
6. Relative Humidity	1	1	-
7. Wind Speed and Direction	1	1	-
8. State of the Weather	2	2	-
9. Precipitation	2	2	x
10. Slope	1	-	-
11. Aspect	2	-	-
Fire Variables			
12. Rate of Spread	-	2	-
13. Flame Length	-	1	-
14. Scorch Height	-	-	x
15. Severe Fire Behavior	-	1	-
16. Direction of Fire Spread	1	1	-
Effects Variables			
17. Weight	x	-	x
18. Number	x	-	x
19. Frequency	x	-	x
20. Density	x	-	x
21. Cover	x	-	x
22. Distribution	x	-	x
23. Plume Trajectory and Dispersion	-	1	-
24. Visibility	-	1	-
25. Water	x	-	x
26. Soil Exposure	x	-	x
27. Soil Temperature	x	x	x
28. Soil Moisture	x	-	x
29. Soil Chemistry	x	-	x
30. Wildlife	x	-	x
31. Economic Costs	1	-	1
32. Economic Benefits	1	-	1

Priority Levels
1. Essential
2. Desirable
x. Essential depending on objectives.

EVALUATION

Evaluation is an essential part of a well-balanced prescribed fire program. Evaluation is the process of analyzing monitoring data to document if resource objectives were met, if prescriptions were correct or need adjustment, if costs were acceptable, and if fire behavior model outputs were verified. The resource specialist(s) should be responsible for analyzing the monitoring data and preparing the documented evaluation report. The evaluation report may include both qualitative and quantitative elements. A qualitative assessment can provide the following information:

1. Prescribed burn boss' narrative of ignition patterns and resulting fire behavior.

2. Estimate of percent of area burned.

3. Description of intensity variations.

4. Description of problems encountered and their resolution.

5. An assessment of probable reasons for marginal burning results.

Quantitative evaluations document results that can be directly compared to objectives, or the results from similar projects. The quantitative evaluation determines the extent of change from some documented pre-fire condition, not just the fact that a change has occurred. Quantitative evaluations may require considerable time and money and cannot be accomplished in detail on all projects. Larger projects which are expected to produce significant effects, or be closely scrutinized, should be monitored and evaluated more intensively using quantitative methods. Every prescribed fire should be evaluated in terms of these questions as a minimum:

1. How well were the objectives met?

2. What were the costs of conducting the project?

3. Are there any changes needed in prescription elements to better meet objectives?

4. Were any safety problems identified?

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