MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

400 - PRESCRIBED FIRE GUIDELINES

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INTRODUCTION

Prescribed Fire, as used in these guidelines, is defined as a fire ignited by persons or by natural causes that is burning in wildland fuels according to approved plans, confined to a specific area, and achieving resource management objectives.

Fire Management strategies for the protection, enhancement, and maintenance of resource values should include a cost-effective and practical mix of fire prevention, presuppression, suppression, and fuels management measures, as well as the prescribed use of fire.

Fire occurrence, fire behavior, damage from fire, and fire suppression costs can be significantly influenced by managing fuels. While fuels management generally deals with vegetative material as a fuel, there are other management considerations. Live and dead vegetation have many values, such as food and shelter for wild and domestic animals. It is a protective soil cover, a source of usable fiber products, a viable source of energy, and a source of soil nutrients, and has certain aesthetic values. Any management activity that alters live or dead vegetation should be evaluated in terms of all resource management perspectives.

The objective of fuel management is to establish and maintain vegetative conditions which are responsive to resource management goals and objectives, and which support resource management activities.

Although this manual is considered a "fire manual," fuels management-related materials can be found throughout. It would be a pointless endeavor to attempt to develop two separate manuals, one for prescribed fire and one for fuels management. These two management practices are so closely interrelated that both subjects are continually interwoven throughout this text. Fire is simply a tool used to accomplish resource management objectives.

Many concepts, procedures, requirements, and policies are contained in this manual. Many are simply formal documentation of the way we have conducted our prescribed fire and fuels management programs for several years. You will also find new concepts, procedures, requirements, and policies contained herein. These are intended to improve the Department's methods of doing business, increase safety considerations, and provide guidance for all Department employees in their daily resource management activities.

405 PRESCRIBED FIRE MANAGEMENT OBJECTIVES

Prescribed Fire is the application of fire to land under such conditions of weather, fuel moisture, time of day, and other factors that will allow confinement of the fire to a predetermined area. At the same time, the application of prescribed fire is intended to produce the necessary intensity of heat and rate of spread required to accomplish certain planned objectives. The use of prescribed fire as a management tool must be based on a sound knowledge of fire behavior as related to fuel, weather, topography, air quality and other factors.

Prescribed Fire Use

DNRC shall provide for the wise, controlled use of fire as a basic tool in resource management practices on State and private lands in Montana. Planning and application techniques and procedures will continually be refined and updated in order to develop, protect, and conserve state forest and range resources as per the State Forest Land Management Plan (SFLMP) and Forest Management Administrative Rules of Montana (ARM). The decision to use prescribed fire must include cost effectiveness and safety considerations.

The following is a list of various management objectives where fire may be a viable management tool option.

1. **Hazard Reduction.** Hazard reduction may involve the use of prescribed fire to aid in the reduction or elimination of the threat of wildfire in areas where fuels have accumulated as a result of management practices or due to natural occurrences.

2. **Site Preparation.** Prescribed fire can be used to prepare an adequate seedbed or planting site for the establishment and development of a new stand of conifer species, which may require exposed mineral soil for regeneration purposes.

3. **Cover Type Conversion.** This objective involves using fire to convert from one cover type to another; brush to grass, brush to trees, or from one tree species to another.

4. **Forage and Browse Improvement.** Prescribed fire can be used to benefit both wildlife and domestic livestock. Prescribed fire is used to improve browse production by releasing valuable or desirable species from competition. Through periodic burning, grass growth can be increased, and decadent grasslands can be rejuvenated. Basal sprouting of shrubs can be promoted through the application of prescribed fire.

5. **Insect and Disease Control.** Although a seldom-used practice, prescribed fire can be used to assist with control of insects, (bark beetles, budworm) and diseases (mistletoe). Usual insect and disease control practices consist of cutting, piling, and burning individual trees or groups of trees. Burning to destroy infected trees can be accomplished at any time of year.

6. **Nutrient Recycling.** This objective is not normally a primary objective, but is often a fringe benefit from a prescribed fire practice. Some of the nutrients tied up in fuels are released to the soil and become available for the establishment and growth of a new stand. An increase in soil pH following the fire occurs but generally is only temporary. Some nutrients are lost in the combustion process, but most remain in the ash and are available to new growing stock.

7. **Understory Control.** The removal of an undesirable understory is a management objective receiving more attention in recent years. The careful application of prescribed fire can assist the land manager in promoting the health and growing potential of an established overstory by removing competing understory.

8. **Fire Behavior and Suppression Training.** Several Department fire suppression training courses utilize prescribed fires for training purposes. DNRC's Initial Attack Engine Squad, Intermediate Wildland Firefighter, Fire Investigation, and the Detection and Dispatch training courses utilize prescribed fires for training purposes. Advanced fire behavior training courses utilize small-scale prescribed fires for training students in the proper methods of determining or estimating rates of spread and flame lengths.

9. **Wildlife Habitat Improvement.** The benefits from using prescribed fire on state or private ground often indirectly benefit wildlife by promoting forage production and basal sprouting of shrubs. State owned and managed wildlife refuges and game ranges could be significantly improved through the application of prescribed fire.

10. **Thinning.** Thinning with fire has received increased interest in recent years. Careful planning and a sound knowledge of fire behavior and effects are required for fire managers to employ fire to attain this objective.

11. **Land Clearing and Right-of-Way Cleanup.** Prescribed fire is regularly used to eliminate or reduce materials left from certain types of land clearing operations and right-of-way cleanup. In these cases, prescribed fire may offer a more economical or desirable treatment than removal or burying.

410 FUEL TREATMENT METHODS UTILIZING PRESCRIBED FIRE

Fire is most often used as a tool to directly manipulate or remove unwanted fuel and waste debris. Several types of prescribed burning (discussed below) are applicable to forest management operations.

General Guidelines for Non-Complex Prescribed Fires

Nearly all hand and machine pile burning conducted by Department personnel falls into the Non-Complex category. The following information is provided as general guidelines for Department employees when conducting burns in the Non-Complex category.

1. The Non-Complex burn boss must be knowledgeable of the objectives of the burn. He/she must be thoroughly briefed on the project if he/she does not have first-hand knowledge of the planned project.

2. A simplified one-page plan (see Appendix A) can be written to address all non-complex burning contemplated for a season.

3. Provision must be made for preburn coordination of appropriate personnel, logistic requirements, and travel arrangements.

4. Specific instructions must be issued to all involved personnel on what to do if the fire exceeds prescription and line holding capabilities.

5. The risk of escape must be fully evaluated, to include potential impacts to adjacent resources.

6. Proper smoke management/planned burning reporting procedures must be adhered to during the established operational smoke management "seasons."

7. Safety considerations must be kept in mind at all times during burning operations. A safety briefing will be conducted (on site) for every prescribed fire prior to ignition. The briefing will include all personnel involved in conducting the burn. Escape routes will be discussed and known to all personnel involved on site with the burn.

8. Unit supervisors will only assign personnel who are qualified to conduct these types of burns. (See Non-Complex burn boss qualifications.) To address safety, a minimum of two personnel should be assigned to any burning project.

9. Mop-up requirements will be determined prior to ignition and adhered to by the burn boss.

10. Weather forecasts will be checked prior to ignition. Pay particular attention to approaching storms, cold fronts and forecast wind direction and speed.

11. The designated Burn Boss will carry a portable radio at all times during burning operations.

12. The burn boss must know the availability and location of the closest backup personnel and equipment.

Handpiling and Burning Guidelines

Basic considerations for piling and burning of slash concentrations:

1. Piles should be tight and compact.

2. Piles should contain sufficient fine fuels for fast, easy ignition and rapid fire spread through the pile.

3. Piling should be accomplished as soon as possible after logging or other fuel treatment. Nutrient retention goals need to be considered.

4. Piles should be sufficiently far from standing trees or reproduction to avoid scorching. Use 15 feet as a guide.

5. Piling should be considered when fuel concentrations are too light or their continuity is such that broadcast burning will not attain desired objectives.

6. Large limbs and branches should be lopped and piled parallel, butts out, to provide a tight, compact pile.

7. The size of the pile is determined by the size of available openings, the volume of slash, and the distance the slash must be moved to the pile. Handpiles should be between 6 to 10 feet in diameter and from 5 to 8 feet high, where possible.

8. Piling should be done sufficiently in advance of burning to allow the slash to dry out so it will burn completely.

9. Piles can be capped with waterproof paper by placing one-fourth of the pile on top of the paper. This practice will allow piles to be burned during periods of time when other adjacent fuels are too wet to burn and control is not a problem or concern.

10. Handpiling and burning along roads, trails, and around recreational or other public areas can help achieve aesthetic objectives by improving the appearance of an area.

Machine Piling and Burning

Mechanical scarification, piling and burning meet many of the burning objectives. Generally machine piling and burning is done on areas where it would not be economical to handpile, and on areas with heavy slash volumes. A dozer can do a very satisfactory job of piling, bunching, or windrowing slash and debris. The best results are usually obtained by using machines equipped with hydraulic blade control and blades with rake teeth extending below the bottom edge of the blade. The hydraulic control generally allows higher lifting of the blade, which facilitates more concentrated and compact piling. A brush blade or blade with teeth extending below the bottom edge enables the operator to pile brush without pushing soil into the piles. Piles containing large amounts of soil will not burn cleanly or efficiently. This will create unnecessary smoke management problems, which cannot be tolerated under current smoke

management programs. It is recommended that Department employees require that rake or brush blades be used on all machine piling projects, where possible.

Procedures for the construction of machine piles are essentially the same as for hand piles. Piles should be located on landings and skid trails, where practical, to limit area of soil impacts. Serious soil damage can result from burning piles that are too large. It is recommended that dozer piles be no larger than 10 feet in height. Care should be taken in the construction of windrows so as not to restrict the movement of animals. There has been a large increase in the amount of excavator piling done. Such equipment can accomplish the same goals as dozer piling, with lower ground impacts and better control over piling.

The most important criterion for a good dozer pile is cleanliness. Where practical or possible, larger piles should be concentrated toward the center of the unit and the smaller piles nearer the perimeter, to aid in smoke management and burn control. More than one convection column should be avoided, as fire whirls may be created which could create control problems. More smoke management "problems" come from the burning of dozer piles than from any other source. Residual smoke during the cool-down phase of dozer pile burning is usually the source of the problem. Smoldering remnants of a dozer pile can and do create problems during nighttime downslope winds or under inversion conditions. Timing of ignition and the duration of smoke production should always be well thought out and anticipated when burning dozer piles.

Jackpot Burning

This burning method is used to reduce fire hazard in areas where heavy fuel concentrations exist but are not continuous enough for a broadcast fire to carry through the fuels, and where piling would be impractical. This burning is normally carried out during the late fall or early spring when fine fuel is dry enough to burn, but larger fuel is too wet to sustain fire. Consideration must be given to the elements of fire behavior, control, and follow-up action. Weather and fuel conditions are usually more restrictive than in other prescribed fire operations, as scorching of the residual stand must be kept to a minimum. It should normally be used only with overstory components of western Larch, Douglas-fir and Ponderosa pine.

Broadcast Burning

All of the objectives for which prescribed fire is used can be achieved to some degree with broadcast burning. Broadcast burning involves spreading fire through a continuous fuel cover over the unit being treated. Broadcast burning is generally applicable only in fuels of fairly heavy concentration possessing good continuity. It has a number of fuel treatment and resource management applications, such as slash disposal on clearcuts, range and wildlife habitat, site preparation, type conversion, and natural fuel reduction. Proper layout of the area to be burned, correct firing methods and timing, and adequate safeguards are essential for satisfactory results. DNRC fire technicians or specialists should be consulted (when necessary) in the initial planning stages in order to evaluate fire concerns and implement recommendations into the overall unit plan. The size and shape of the area should be planned to make the burning job as practical and economical as possible and in harmony with other management needs. Conditions that would make it difficult to confine the fire to the planned area should be recognized and minimized. In

steep terrain, flank lines should be reasonably straight and run at right angles to the contours. Where irregular flank lines are necessary to meet other management objectives, fuels lying outside of a logical control line must be moved inside that line or otherwise specially treated. Concentrations of fuels adjacent to control lines that could cause problems during burning should be scattered or otherwise treated prior to ignition. Snags or other trees that could pose control or safety problems should be felled.

Due to the complexity involved in broadcast burning, a qualified burning boss will be identified to conduct (see Burn Boss qualifications section) the burning operation.

DNRC employees have utilized aerial ignition devices on several broadcast burns. A fully qualified Prescribed Fire Burn Boss Type 1 (RXB1) is required due to the complex nature and significant fire behavior differences between aerial ignition and conventional ground ignition techniques. Prescribed fires that utilize aerial ignition devices will always be considered Complex Prescribed Fires.

Understory Burning

This method of burning is used to reduce fuel; provide site preparation for regeneration and thinning; eliminating unwanted vegetation; and improving range and wildlife habitat on sites where an overstory is present. Fire behavior variables included with the loading, size, continuity, and arrangement of fuels are important considerations that, combined with climatic parameters, should prevent crown scorch and cambium kill in the residual stand and achieve management objectives. Other factors that affect resistances to fire damage include, but are not limited to, species, age, and diameter class. Only three species in Montana (Western larch, Douglas-fir, and Ponderosa pine) show marked resistance to cambial damage resulting from fire. Resistance to crown scorch also varies between species. Residual stand characteristics and fuel loading by size class should be carefully considered in developing understory burning prescriptions. As a general guide, extreme caution should be exercised when understory burning where fuel loadings in the less than 3-inch category are 15 tons per acre or greater, or total fuel loadings are in excess of 40 tons per acre.

Progressive Burning

This method (also called Swamper Burning) consists of piling and burning slash and debris in one operation. It is commonly used in the late fall or winter when a good fuel cleanup is desired and when there is no danger of fires spreading. Progressive burning is feasible in fairly dry weather if an engine is located or maintained on the site and burning is continually watched. It is a method often used on land clearing and rights-of-way cleanup. Generally, slash is placed directly on the burning pile. A very hot fire is needed if much damp or green material is to be burned. The fire should be kept compact by chunking in the larger material in order to ensure complete disposal. Care must be taken when burning wet or green material so as not to create smoke/air quality problems.

415 PRESCRIBED FIRE BURN TYPE

Whether a prescribed burn is classified as complex, intermediate or non-complex is determined by the following factors:

1. The resource management objectives of the burn.

2. Factors that determine the risk of escape:

    a. Shape of the burn unit.
    b. Accessibility.
    c. Time of year.
    d. Potential fire behavior as determined by weather, fuels, and topography.
    e. Time of day.

3. Resource values at risk.

4. Proximity and value of non-state lands.

5. Type of ignition operation.

Prescribed Fire Burn Plans drafted by DNRC employees shall have the COMPLEXITY LEVEL determined and noted on the front page of the plan.

The three types of burns are defined as follows:

1. **Complex**. Complex projects include those in which there are difficulties in achieving management objectives and those in which fuels, weather, topography, and hazard to adjoining resources dictate the use of extreme care. Often there is a potential for escape that must be carefully evaluated.

    These burns may include those located on two or more aspects, within v-bottom canyons, or low on the slope. Burns possessing heavy fuels, steep slopes, or irregular boundaries are also included here. Accessibility of the unit, availability of water and the condition of the fireline are additional factors to be considered in determining the type of burn. The size of the area to be burned should be considered in conjunction with the factors mentioned above. Difficult situations may be encountered in attempting to burn small units or very large units.

    Understory burns will be rated Complex when flame lengths and fire intensities pose special problems to management objectives and resource values, or when other factors establish the potential for significant adverse outcomes.

2. **Intermediate.** This designation includes burns where management objectives and control problems are not complicated. This may include burns conducted in the spring or fall or burns where topography or a change in fuel conditions limits fire spread. Some control problems may be present due to location, aspect, or the presence of adjacent partial or clearcut blocks containing untreated slash.

Because of topography, fuel volume and arrangement, presence of untreated slash, or management direction, Intermediate burns generally require detailed planning and careful execution.

3. **Non-Complex**. Burns may be considered Non-Complex when escape and resource damage is unlikely to occur. These burns are usually conducted in early spring or late fall. These burns generally are confined to hand piles and machine piles whose perimeters are well cleaned.

420 PRESCRIBED FIRE BURN PLAN

Prescribed Fire Burn Plan Requirements

A Prescribed Fire Burn Plan will be drafted and approved for all prescribed fire conducted by state employees on state or private land, with the exceptions noted in this section.

Prescribed Fire Burn Plan Format

The Prescribed Fire Burn Plan includes required elements for conducting prescribed fire (see Appendices).

The forms in Appendix A and B contain the elements to be considered when developing a Prescribed Fire Burn Plan. The required resolution and precision of needed information will vary with each plan.

Approval Procedures

The Prescribed Fire Burn Plan will be reviewed and approved by appropriate personnel within the Department according to the Approval table.

Approval requirements will vary depending on the complexity level of the proposed prescribed burn. The following procedures will apply to all DNRC personnel for every prescribed burn conducted on state or private land or for situations in which state employees are responsible for the planning, execution or approval of a fire treatment involving state land.

1. Each administrative level of the DNRC will review and approve any Prescribed Fire Burn Plan written at that level prior to sending the plan to the next level for approval (if required). For example, if a Prescribed Fire Burn Plan was written by a person on Clearwater Unit, the plan would have to be approved by the Clearwater Unit Manager. If the plan required further approval, then it would be sent to the Southwestern Land Office. After review and approval at the land office, the plan, if required, would be sent to the Fire & Aviation Management Bureau for review and/or final approval.

2. Every Prescribed Fire Burn Plan will be rated as to the complexity of the proposed prescribed burn. (See section on Complexity Levels.)

3. The Prescribed Fire Burn Plan is approved when signed and dated by the approving authority.

APPROVAL TABLE

BURN TYPE	TECHNICAL REVIEW	APPROVAL
Complex	R_XB1 (If aerial ignition FAMB Review)	AREA MANAGER
Intermediate	R_XB2	UNIT MANAGER
Non-complex	R_XB3	UNIT MANAGER

NOTE: This table contains both technical review and administrative approval procedures. Any changes to the approved Prescribed Fire Burn Plan must be authorized by the approving line officer except for immediate revisions to the firing patterns and containment forces that must be made by the burn boss on the site to respond to any unforeseen situations. Any aerial ignition requires Fire and Aviation Management Bureau technical review.

Escaped Fire

An escaped fire is defined as a fire burning out of the planned prescription and/or outside of pre-determined boundaries, and is burning in a manner which is beyond the capabilities of on-site personnel to quickly contain. An escaped fire will normally require deviation from or suspension of the planned prescribed fire operations.

Funding

The following table will determine funding sources for escaped fires that occur on state lands.

FUNDING TABLE

PRESCRIBED FIRE (PLANNED ACRES)	ADDITIONAL ACRES LOST (BY ESCAPE)	CHARGE ADDITIONAL COSTS TO
1-25	1-25 25+	Forest Improvement Acct. Fire Suppression
26-75	1-50 50+	Forest Improvement Acct. Fire Suppression
76+	1-75 75+	Forest Improvement Acct. Fire Suppression

425 MOP-UP STANDARDS

The following categories establish minimum mop-up standards for the DNRC to ensure that appropriate actions are conducted on prescribed fires in a timely manner to eliminate or reduce the potential for escaped fires as documented in the Prescribed Fire Burn Plan.

1. **Category 1**. Burns with a high potential for escape or adjacent to improvements, private land, or high value resources that could be damaged substantially by fire should be carefully evaluated for Category 1 status. The presence of private land alone does not automatically place a burn in Category 1. Social and political factors and management direction may require a Category 1 status.

    a. Complete (100%) mop-up of entire unit and all spots and slop-overs. If available, a daily infrared inspection is recommended until a dead out declaration is made.

    b. Mop up 3 chains in from boundary within 48 to 72 hours after completing burn.

    c. Have burn in condition to handle a dry cold front or strong winds within 72 hours of burning.

    d. Conduct mop-up actions in a timely manner to reduce the risk of later escapes.

2. **Category 2**. Many spring and fall broadcast burns are included in this category. Summer burns can be in this category if fuel moisture levels were adequate to make the risk of escape unlikely. Hand and/or dozer piles can be in this category based on special circumstances, as determined by the responsible DNRC manager.

    a. Complete (100%) mop-up of all spots and slopovers until dead out.

    b. 100% mop-up within 1 chain of the perimeter on the downwind side of the unit.

    c. Have burn in condition to handle potentially difficult fire weather situations (dry cold fronts, strong winds, low humidities) within 72 hours of burning.

    d. Additional considerations under Category 2 mop-up:

        - Unburned islands should be either lined, burned out, or the area outside the unburned fuel must be mopped up.

        - The time of year and how long before an expected weather change occurs.

        - Long, dry falls have a history of dry cold fronts occurring after an extended drying period. Many escapes have resulted from this type of weather pattern.

        - Condition and amount of fuels outside burn area.

- Require patrols to walk the line.

- Strengthen mop-up actions under red flag forecasts.

e. Patrol the prescribed burn and use infrared monitoring as needed until declared out or wet weather reduces need for surveillance.

3. **Category 3**. Spring wildlife burns in light fuels and pile burning with snow or high moisture conditions fall in this category, along with jackpot burns. Risk of escape and/or values at risk are extremely low.

   a. Minimal or no mop-up may be satisfactory to contain the burn to the unit.

   b. Patrol and monitoring are required until the fire is dead out.

After Action Reviews (AAR)

After action review will be scheduled and conducted by unit and/or land offices at their discretion. The Forestry Division Fire and Aviation Management Bureau Chief may schedule and conduct an AAR for any prescribed fire.

435 BURN BOSS QUALIFICATIONS

DNRC Burn Bosses will be qualified per the NWCG "Wildland Fire Qualification System Guide (PMS 310-1, April, 2006) or as defined in this section.

DNRC Area Managers have the authority for administrative approval of prescribed fire operations conducted on their Land Offices. DNRC Land Office and Fire and Aviation Management Bureau Training Representatives will maintain qualifications for prescribed burning for all personnel under their administrative control. From the technical approval standpoint, DNRC employees writing or approving Prescribed Fire Burn Plans or functioning as Burn Boss on prescribed fire operations will be considered fully qualified when they meet the following criteria commensurate with the approved type of prescribed burn.

Burn Boss - Definition

The Burn Boss is the person designated by proper authority who is responsible for planning, executing, and evaluating prescribed fire projects. A DNRC Burn Boss supervises all personnel assigned to a specific prescribed burn. He/she must be familiar with management objectives for a specific project, and is responsible for developing a Prescribed Fire Burn Plan that will accomplish the stated objectives. He/she will be qualified, according to standards contained within these guidelines, commensurate with the complexity level of the specific prescribed fire project. He/she should be selected early in the planning process to work closely with the Unit Fire Supervisor in order to insure that fire considerations are integrated into the overall planning process. The Burn Boss must work closely with resource and technical specialists when necessary to ensure harmony with resource objectives and organizational policies, regulations,

and constraints. The Burn Boss should personally inspect the area to be burned and determine fuel loads, control line locations, firing techniques, ignition patterns, and personnel and equipment requirements. The Unit Fire Supervisor or the Burn Boss is responsible for developing the Prescribed Fire Burn Plan. A Burn Boss should not be required to implement a Prescribed Fire Burn Plan that he/she did not plan, develop, and write without prior burn plan review and discussions with the Unit Fire Supervisor. The Burn Boss is responsible for understanding all aspects of the burn plan.

The Burn Boss is responsible for the execution of the burn, including organization and supervision of crews; providing equipment; ignition; and patrolling and monitoring the weather before and during the fire until it is declared out, or until he/she is properly relieved of those responsibilities. If a prescribed fire exceeds the prescription, the Burn Boss is responsible for taking necessary actions to control the fire.

The Burn Boss is responsible for recording fire behavior and weather observations during the fire, and also for recording post-fire measurements of fire effects. He/she should assist in determining if the objectives for the project were met. An accurate documentation and analysis of project costs is also the responsibility of the Burn Boss.

Firing Boss - Definition

The Firing Boss is the person responsible for the actual ignition of a prescribed fire, and for regulating the fire intensity in accordance with the Prescribed Fire Burn Plan. The Firing Boss could supervise several crewmembers and/or decide to assist with ignition depending upon the size and complexity of the burn. He/she should review the Prescribed Fire Burn Plan with the Burn Boss and help determine personnel and equipment requirements for ignition. The Firing Boss must have had previous fire experience in the fuels and a vegetative type in which burning is to take place. The Firing Boss is directly responsible to the Burn Boss.

PRESCRIBED FIRE BURN BOSS TYPE 1 (RXB1)

(Position Category: Wildland Fire)

REQUIRED TRAINING

Advanced Wild Fire Behavior Calculations (S-490)
Annual Fireline Safety Refresher (RT-130)

REQUIRED EXPERIENCE

Satisfactory performance as a Prescribed Fire Burn Boss Type 2 (RXB2)
plus
Successful position performance as a Prescribed Fire Burn Boss Type 1 (RXB1) on a prescribed fire incident

PHYSICAL FITNESS LEVEL

Light

OTHER POSITION ASSIGNMENTS THAT WILL MAINTAIN CURRENCY

Prescribed Fire Burn Boss Type 2 (RXB2)

Any higher position for which this position is a prerequisite.

OTHER TRAINING WHICH SUPPORTS DEVELOPMENT OF KNOWLEDGE AND SKILLS
Fire Program Management (M-581)
Fire in Ecosystem Management (M-580)
Applied Fire Effects (RX-510)
Smoke Management Techniques (RX-410)

PRESCRIBED FIRE BURN BOSS TYPE 2 (RXB2)

(Position Category: Wildland Fire)

REQUIRED TRAINING
Introduction to Wildland Fire Behavior Calculations (S-390)
Annual Fireline Safety Refresher (RT-130)

REQUIRED EXPERIENCE
Satisfactory performance as a Firing Boss, Single Resource (FIRB)
plus
Satisfactory performance as an Incident Commander Type 4 (ICT4)
plus
Successful position performance as a Prescribed Fire Burn Boss Type 2 (RXB2) on a prescribed fire incident.

PHYSICAL FITNESS LEVEL
Moderate

OTHER POSITION ASSIGNMENTS THAT WILL MAINTAIN CURRENCY
Any higher position for which this position is a prerequisite.

OTHER TRAINING WHICH SUPPORTS DEVELOPMENT OF KNOWLEDGE AND SKILLS
Fireline Leadership (L-380)
Prescribed Fire Burn Plan Preparation (RX-341)
Introduction to Fire Effects (RX-310)
Prescribed Fire Burn Boss (RX-300)

PRESCRIBED FIRE BURN BOSS NON-COMPLEX (R_XB3)

(***NOTE***: *This is a DNRC-specific position. This position is not listed within NWCG 310-1.)*

1. Will have experience burning in the fuel type in which assigned (machine piles, hand piles, rangeland, etc.).

2. Will have received training in the safe handling and operation of assigned burning equipment.

3. Will be a fully qualified FFT2 per NWCG "WILDLAND FIRE QUALIFICATION SYSTEM GUIDE (PMS 310-1, April 2006") or have completed the DNRC Basic Wildland Firefighting (BWFF) Course or equivalent.

4. Will have demonstrated the ability to supervise small groups of people.

5. Will have demonstrated the ability to exercise sound judgment.

440 SAFETY

Prescribed fires will not be ignited unless they can be done SAFELY. Don't ignite the fire until you've explored every means of protecting people, equipment and resources. Safety measures that apply both to fire suppression and prescribed burning are:

1. In assigning personnel to prescribed fires, consider their health and physical ability. DNRC ignition and holding crews will have met current DNRC physical fitness requirements for arduous labor. Other support personnel should be judged to be in satisfactory health and have adequate physical ability for the position or duties to which they are assigned.

2. Be sure that protective clothing and equipment such as hard hats, boots, gloves, Nomex clothing and face masks or goggles are used as required. Each DNRC employee on the line will wear a fire shirt and other appropriate safety clothing and equipment. All DNRC personnel on complex and intermediate burns will carry fire shelters.

3. Consider the characteristics of the area to be burned which may be hazardous, such as snags, heavy fuel concentrations, poor footing, and loose rocks.

4. Be sure every person knows his/her escape route(s) and safety zones.

5. Explain the safe use and any peculiarities associated with the various firing devices.

6. Warn personnel against the inhalation of smoke over extended periods.

7. Stress the necessity of following instructions and staying in touch with the crew, line overhead, etc.

8. For aerial ignition operations, be sure at the prefire briefing that all personnel are aware of the special safety concerns and requirements for this type of operation.

Don't assume that any person is aware of the burning plan. Every person involved on-site in a prescribed burn should attend the prefire briefing and be aware of the safety considerations and instructions. The pre-fire briefing will include a through review of the 10 Standard Orders and the 18 Situations That Shout Watch Out.

445 CONTROL PRINCIPLES

Prior to ignition, a determination of rates of spread and fire intensity for potential spot fires will be calculated. This calculation is required on all complex and intermediate burns. A behave calculation should be completed and included as part of the Prescribed Fire Burn Plan.

The control needs of each fire should be carefully assessed during the planning period. Each potential fire escape point should be identified and mitigation planned. Remember that proper control of prescribed fires depends on skillful execution of the burning plan and is directly related to the expected fire behavior.

FIRE SUPPRESSION INTERPRETATIONS OF FIRELINE INTENSITY & FLAME LENGTH		
Fireline Intensity (BTU/Sec/Ft)	**Flame Length (Feet)**	**Interpretation**
< 100	< 4	Persons using hand tools can generally attack fires at the head or flanks. Handline should hold the fire.
100 - 500	4 - 8	Fires are too intense for direct attack on the head by persons using hand tools. Handline cannot be relied on to hold fire. Equipment such as dozers, engines, and retardant aircraft can be effective. Fires are potentially dangerous to personnel and equipment.
500 - 1000	8 - 11	Fires may present serious control problems, i.e., torching, crowning, and spotting. Control efforts at the head will probably be ineffective.
> 1000	> 11	Crowning, spotting, and major fire runs are probable. Control efforts at head are ineffective.

Natural Controls

Natural barriers should be used whenever possible. If there is an opportunity for the use of rock slides, ridge tops, streams, and brush fields, incorporate them into the control plan. Snowbanks on ridges have been effectively used in lieu of installed control lines or blacklines for range burning.

Installed Controls

Installed controls include advance construction of control lines and pretreating areas adjoining or within the planned burn. A little used but potentially effective control is the use of blasting cord for installing control lines on steep slopes. Blasting line may be more economical than dozer line construction and may do less damage to steep slopes or other sensitive areas. Directional falling of trees adjacent to firelines may facilitate mop-up at a later date. Whenever possible, avoid concentrating slash on the edges of burn units.

Briefings

Prior to the execution of any burn, a complete on-site briefing of the entire crew will be conducted. The briefing should occur before positions are taken and ignition begins and, if possible, take place at a site overlooking the burn unit. Key points on the map and ground will be identified and the ignition sequence reviewed. Plans will be discussed so each person will know what to do in the event of an escaped fire. A safety briefing is required prior to every burn conducted by DNRC personnel.

Communications

The communication plan should be reviewed during the briefing. and persons assigned to carry radios should be identified to all persons involved in the burn. If the prescribed fire is to be ignited with a helitorch or a ping-pong ball machine, a separate radio frequency will be assigned for the pilot to talk to the Burn Boss. All radio traffic on the line will be conducted on the assigned frequencies. No one will talk on the assigned aircraft frequency except the Burn Boss and the pilot, except in case of an emergency or radio malfunction. All pilots should be instructed to immediately stop ignition if radio communications with the Burn Boss fail.

Test Fires

The need for a test fire should be discussed in the Prescribed Fire Burn Plan. Test fires may be needed to verify if conditions are acceptable for burning. Where a number of burns are planned in an area under similar conditions, a test fire is not necessary for each burn.

Scheduling Prescribed Fires

Scheduling of a prescribed burn is closely tied to the objectives and desired results of the particular project. A prescribed burn is scheduled at the time of year when it will produce the desired results. Burning plans for all burning seasons should be completed well ahead of the tentative ignition date, in order to complete the approval process and to allow time for any revisions that may be required.

1. **Spring Burns**. This is done prior to the normal fire season, usually after a drying period but before the spring rains. Under natural fuel accumulations the large fuel, duff, and soil are generally wet at this time, but the fine fuel is dry enough to sustain fire. These fires seldom generate intense heat, but they do burn fine fuel and the surfaces of larger fuel so as to reduce the hazard of wildfire. Duff reduction and site preparation are possible on south and

west exposures on broadcast burn units under favorable conditions. This is an excellent time to conduct rangeland prescribed fires. High soil moisture helps protect the roots and root crowns of desirable grasses, and snowbanks on ridges can be used as control lines. Care must be taken not to conduct spring rangeland burns if greenup has proceeded beyond 1 inch.

Fuelbreak and firebreak maintenance should normally be accomplished during the spring burning season. DNRC employees should encourage railroad companies to accomplish railroad right-of-way burning and other maintenance requirements as early in the spring as possible, but always prior to the seasonal increase in fire danger. DNRC employee involvement in railroad right-of-way burning will only be in an assistance capacity. Right-of-way fire hazard reduction and maintenance on railroads is the responsibility of the railroad company.

2. **Summer Burns**. This burning is done during the normal fire season. Large fuel and duff are dry to a substantial depth. Annual growth may be curing, and the surrounding forest areas are dry. Summer burning can reduce the duff to a considerable depth. Generally, cost per acre is higher for this burn and risk of escape is increased.

3. **Fall Burning**. Burning is initiated following a definite break in weather that produces cooling temperatures and significant moisture and marks the end of the normal fire season. The weather is in a transitional stage that can produce lengthy periods of rain interspersed with periods of moderate to high fire danger. Duff reduction and site preparation are burning objectives that can be readily obtainable during this period.

4. **Winter Burning**. Burning is initiated after the November 30th deadline for fall burning and is very limited due to air quality issues. This burning normal consists of non-complex burns that can not be completed any other time of the year, and when snow is on the ground.

450 SMOKE MANAGEMENT

All DNRC employees will adhere to the goals and procedures of the Montana/Idaho State Interagency Smoke Management Program, as per the hyperlink below.

http://www.fs.fed.us/r1/fire/nrcc/smoke_web_pages/OpGuide.pdf

The goals of the Montana State Interagency Smoke Management Program and the State Airshed Group are to:

1. Minimize or prevent the accumulation of smoke in Montana when prescribed burning is necessary for the conduct of accepted forest practices.

2. Develop a smoke management plan for reporting and coordinating burning operations on all forest and rangelands in the State.

All prescribed burning by DNRC employees will be in accordance with current policies and procedures of the smoke management program. The cooperative effort of all organizations involved in the use of prescribed fire is essential for the continued success of the program. The state's annual air quality permit is dependent on each employee being knowledgeable of the smoke management program and complying with all requirements. The continued use of fire as a management tool is dependent on the voluntary compliance by all fire managers with all requirements and policies established by the smoke management advisory board.

455 USE OF PRESCRIBED FIRE FOR RANGE IMPROVEMENT ON STATE LANDS

The DNRC is, by law, authorized and directed to manage state-owned land so as to develop or conserve state-owned resources such as grazing land and timber land "to the benefit of the state." The Department is further authorized to incur expenses "in order to develop or increase the value of the land or the revenue therefrom." MCA, Part 6, Section 77-1-601, Statement of Policy for Development of State Lands, states: "It is in the best interest and to the great advantage of the state of Montana to seek the highest development of state-owned lands in order that they might be placed to their highest and best use and thereby derive greater revenue for the support of the common schools, the university system, and other institutions benefiting therefrom, and that in so doing the economy of the local community as well as the state is benefited as a result of the impact of such development."

Prescribed fire rangeland studies conducted by DNRC employees in recent years have shown how prescribed fire, when properly planned and conducted, can dramatically improve the quality and quantity of useable forage on rangelands in Montana.

Goal

One goal of the Department is to serve the best interests of the State by managing the state-owned rangeland resource in the manner defined by state law, as manpower, budgets, and workplans allow.

Objective

The DNRC utilizes prescribed fire as a management tool to improve the condition of state-owned rangeland resources, through planned range improvement practices, in order to maximize long- term revenue for the school trust.

Discussion

Prescribed fires on state-owned land can be used to accomplish this goal and meet objectives of several fire and resource management programs of the DNRC. The program objectives for the Department's Rural Wildland Firefighting Training Program requires trainees to demonstrate knowledge and understanding of fire suppression techniques and procedures by successfully completing a simulated wildland fire suppression exercise, or by participating in an actual on-the-ground prescribed fire exercise.

Department field offices periodically receive inquiries from lessees of state land concerning range improvement practices and procedures. In many cases the lessee wants to use prescribed fire to control or reduce sagebrush, tree encroachment, or to generally rejuvenate decadent state rangeland. In several areas of the state, state-owned rangeland is in less than good range condition due to past management practices. Fire can be used to reduce sagebrush on significant acreage of state-owned land. Carrying capacities could be significantly increased due to increased forage resulting from the fire treatment. Revenue from these lands to the state school trust could be increased over present levels, and state-owned land would be more productive over the long run.

Procedures

Procedures for accomplishing portions of these Department goals and objectives with the use of prescribed fire are outlined below.

1. **State Land Lease Renewals**. The Department will maintain a file of state land which could be improved by the application of prescribed fire, based on the following procedures: When a state land lease comes up for renewal, the field office Land Use Specialist normally will do a field evaluation of the site. If, this field inspection determines that the site could be improved with a fire treatment, a copy of the field evaluation form will be retained in a file designating potential sites for range improvement projects using fire.

2. **Lessee Initiated Request for Improvement**. Lessees desiring to use fire to reduce or control sagebrush, aid in the abatement of noxious weeds, tree encroachment, or to generally rejuvenate decadent state-owned rangeland should contact the appropriate land office and complete a Request for Improvement form.

   The land office will review the request with the lessee to initially determine if a fire treatment is appropriate for the site. A supplementary lease agreement may be initiated which outlines the responsibilities of all parties and deferment of grazing rentals on the State lease. Information on state cost-share assistance through the Resource Development program and/or the Montana Rangeland Resource Program (DNR&C) may be provided.

3. **Criteria Common to Either Procedure**. The feasibility or potential benefit from fire treatments needs to be determined for any proposed range improvement project. The following considerations should be appraised to help determine if burning is appropriate.

   a. Range sites with sagebrush cover in open stands with a good understory of perennial grasses and forbs, rated in good or excellent range condition should not be considered for fire treatment, unless special circumstances exist.

   b. Potential sites for fire treatment should be carefully planned so as to prevent any adverse impacts to riparian areas or wildlife habitat. The local office of the Fish, Wildlife, and Parks will be contacted for advice and input.

   c. The fire treatment should result in an increase in AUM's on the site.

d. Alternative treatment should be considered, as with any management plan. Prescribed fires will only be conducted on sites where prescribed fire is selected as the best alternative to meet the planned objectives.

e. Areas with less than 30% crown cover of sagebrush should not be considered for a fire treatment.

f. Planners should be aware of potential impacts from big game use following a rangeland burn. As a rough guide, a minimum of 100 acres should be considered for burning in big game winter use areas. Multiple burns in a local area may help in ensuring that big game use does not become concentrated on a single area.

g. If a fire treatment is found to be appropriate, then a Prescribed Fire Burn Plan meeting the Department's Prescribed Fire Guidelines will be prepared based on the objectives established for the site.

h. An environmental assessment checklist (EAC) will be completed as required.

i. The Prescribed Fire Burn Plan will require an on-site inspection to determine the range condition in the proposed burn area. The range condition will be based upon current range evaluation procedures. The potential for each range site and the current trend of the present plant community will be estimated. Both erosion potential and utilization should be considered. The range management portion of the Prescribed Fire Burn Plan will be developed and appended to the Prescribed Fire Burn Plan. The range portion of any Prescribed Fire Burn Plan produced by an outside agency or individual will be reviewed for technical content and accuracy by the unit Land Use Specialist and approved by the Area Manager (or designated representative) prior to acceptance. This "review" obviously must look at the entire plan; however, any DNRC "approval" will refer only to the fire effects portion of the Prescribed Fire Burn Plan. Approval does not constitute approval or endorsement of any other portion of the plan such as control measures, ignition plan, equipment requirements, contingency plans, etc. The fire effects portion of the Prescribed Fire Burn Plan will be reviewed and approved per these guidelines.

   If the Prescribed Fire Burn Plan/Range Plan and Supplementary Lease Agreement require deferral of grazing on the site to be treated, two growing seasons will be the standard grazing deferral time. Reappraisal of AUMs will be done during the third growing season. The new animal unit rental will be applied for the fourth growing season. Deferral of rentals will be evaluated and determined on a total lease impact basis through the Supplementary Lease Agreement. The Lessee will be required to sign a supplemental lease agreement stating he/she agrees not to graze the tract during the first two growing seasons. This statement of intent should become an addendum to the lease. The site may require one year of rest prior to burning in order to ensure that enough fine fuel is present to carry the fire.

j. Range management plans will be an addendum to an existing lease. Following review and approval, these must be forwarded to the appropriate Trust Lands Division employee at the land office for further action in accordance with the procedure for adding an addendum to a lease. A copy of all Prescribed Fire Burn Plans/Range Management Plans will be placed in the lease file. Any Prescribed Fire Burn Plan involving classified state grazing land must be sent to the Lands Division for review.

k. The lessee is responsible for conducting the range improvement project unless other arrangements are made between the lessee and the Department.

l. Adjacent landowners should be contacted regarding the proposed prescribed fire.

m. The Land Office will send a qualified burn observer to participate on range improvement burns on state land as deemed necessary by the Area Manager.

n. Proper permits must be obtained by the lessee.

o. Other land office personnel and equipment may be used at the discretion of the Area Manager.

p. Following the burn, the Area Land Use Specialist will reappraise and evaluate range condition and AUM rental as required in the Range Plan and/or any addendum to these.

460 IGNITION METHODS AND TECHNIQUES

Ignition Devices	Comment
Matches	Always available in quantity, rapidly dispensed, inexpensive
Fusees	May be extended on pole, light in weight, hot, concentrated flame, may be thrown, inexpensive.
Propane Torches	Very hot flame, long burning, (backpack) good for piled slash and some broadcast burns, heavy and awkward, time-consuming refill.
Jellied Petroleum	Good for piles and broadcast burns; hot, long duration flame.
Diesel Flame-Thrower	Easy refill, residual flame, (backpack) heavy and awkward, require pressurizing.
Drip torches	Light and portable, fuel mixing, need frequent refills.

Helitorch	Added manpower required for support, hot long duration flame, rapid ignition, high intensity fire, extends burning window, and increases burn complexity. Added safety in hazardous units exists by not having igniters on the ground.
Plastic Sphere Dispenser	Rapid ignition, low intensity flame, requires fine fuels for ignition, safety concerns with equipment malfunction in aircraft, increases complexity of firing operation, reduces ignition time for large units.

Firing Methods

1. **Backing Fire**. The backing fire technique consists of lighting the downwind side of an area and allowing the fire to burn into the wind. Backing fires will generally advance at a slow rate of-spread depending on the integrating effects of fuels, weather, and topography. Because of its slow advance, a backing fire is relatively easy to control and can be safely executed under windier and dryer conditions than other methods. The strip backing fire can be useful when burning under a canopy because convective heat can be more controlled. A backing fire tends to have a longer residence time on a site and therefore total heat released at any one point is greater than with other firing methods. Fuel consumption is generally more complete with a backing fire than with other methods.

2. **Strip Head Firing**. The strip head fire method consists of lighting a strip of fire and allowing it to spread with the wind or slope until it is stopped by a previously burned strip or a prepared fireline, blackline, or natural barrier. This technique can be used when it is desirable to burn large areas in a short time. In order to burn out the safety strip, a backing fire (or very narrow carefully controlled strip head fires) should be started on the extreme downwind side before the first strip head fire is ignited. After the safety strip is prepared, strip head fires can be ignited at widths determined by the burn boss. Head fire intensities will be greater than that observed with other firing methods. Caution is required if using this technique for understory burning. Slight changes in conditions can result in unacceptable crown scorch. Due to rapid rates-of-spread between strips, head fires may not be effective for consuming large size class fuels lying on or close to the ground. The angle of the line of strip fires can be altered to adjust for minor changes in wind direction. Whether using strip head fires by ground or aerial ignition, patience is the key to controlling the intensity and rate-of-spread and usually determines the ultimate success or failure obtained from using this technique.

3. **Spot Firing**. The spot firing method is an exacting procedure that requires considerable experience by the prescribed burner. This method employs a series of small spot fires that burn in all directions as they come together, minimizing the possibility of any one spot gaining sufficient momentum to start a hot run. Timing and spacing of the individual fire spots are the keys to successful application of this method. If used in a residual stand, care should be taken not to space spots closer than two to three chains, which would create more junction zones of increased intensity, nor too far apart, allowing individual spots to build up hot fire heads. A skilled crew can treat a large area in a short time using this technique. Inexperienced prescribed burners should utilize some other technique until they gain

considerable experience in fire behavior. This method can be used with light, variable winds. Fuels should be generally continuous and light to medium. The burner must secure both the base line before area firing and the entire perimeter as firing progresses.

4. **Center Fire**. Center firing (also called Ring firing) requires considerable knowledge of fire behavior. When used properly, center firing can be the most effective and reliable technique for broadcast burning, and is particularly useful for burning heavy slash concentrations when wind speed is low. This method works well when wind direction is variable. However, caution should be taken, as variable winds may indicate atmospheric instability. Center firing consists of simultaneously lighting several fires in the center of an area to be burned. When it is evident that air is being drawn inward, the outer portions of the unit are ignited, followed by ignition of the perimeter. A strong convection column is created, and fuel is rapidly consumed. For a strong, intense fire, proper spacing and speed of ignition are critical.

5. **Flanking Fire**. The flanking fire technique consists of lighting a strip of fire parallel to the wind, which burns outward at right angles to the wind. This technique combines the effect of both the headfire and backing fire. A good knowledge of fire behavior is important, and the flanking fire should be used only if winds are steady from one direction. This technique is often used to secure the flanks of a strip head fire or a backing fire as it progresses. Close control of firing personnel is required to achieve the proper spacing and timing. Radio communication with each ignitor is required on large areas. This technique should always progress from a secured baseline.

6. **Chevron Burn**. This method of prescribed burning is designed for use in hilly areas to fire ridge points or ridge ends. Lines of fire should be started simultaneously from the apex of a ridge point and progress downhill. The Chevron burn involves a flank fire concept, except that the lines of fire are not parallel. Any two lines of fire converge at a point rather than along a line, resulting in the junction zones or areas of increased intensity remaining small.

465 NON-BURNING METHODS OF FUEL TREATMENT

Several methods of forest site and/or fuel treatment are available to Department land managers. A brief description of the most common non-burning methods for site and fuel treatments follows.

1. **Natural Decomposition**. Allows fuels to remain intact and in place and decompose slowly through natural processes. This no treatment option may need to be coupled with supplemental protection.

2. **Handpile Without Burning**. This method will break up the fuel's horizontal continuity.

3. **Lop and Scatter**. Rearranges fuel continuity, increases fuel moisture by bringing slash in contact with the ground, and accelerates decomposition. Both may or may not be done together; i.e., may be lopped without being scattered.

4. **Trample or Crush**. This method accelerates decomposition and changes fuel continuity and moisture content by dozer walking, rolling, etc.

5. **Chipping**. Changes fuel continuity and fuel size and accelerates decomposition.

6. **Masticating or Shredding**. A method that increases fuel deterioration and changes fuel continuity by mechanically breaking up the fuels.

7. **Fuelbreak/Firebreak**. This fuel management method changes the continuity of fuels to enhance control of fire spread. Fuelbreaks and firebreaks may remove considerable acreage from effective production, but may be justified as needed for fire control purposes.

8. **Supplemental Protection**. A method of non-treatment based on the calculated risk that fire suppression will be more economical than fuel treatment. Increased patrolling may be required during periods of moderate to high fire danger.

9. **Dozer Scarification**. This method is more properly considered a site preparation measure to expose a more beneficial seedbed or to aid in planting accessibility.

10. **Chemical Treatment**. This method utilizes chemicals to speed deterioration or to provide fire resistance. As a fuel management technique, chemicals can be used to desiccate herbage prior to the prescribed burning.

11. **Utilization**. Increases in the standard of utilization reduce the fire potential of a site; however, recent research has shown that a certain amount of fuel left on a site can be beneficial to seedling establishment and survival.

12. **Burying**. Burying of fuels can be applicable in road construction. This method may also be feasible in areas of heavy fuel concentrations where burning is critical. Buried fuels have plagued fire control efforts for many years. If burying is required, care must be taken to ensure that the materials have sufficient mineral soil on top of the area to prevent fire from penetrating to the buried materials.

13. **Slash Filter Windrow**. Road right-of-way slash placed and compacted at the toe of a fill slope. This method is used where opportunity for sediment delivery to stream channel exists. Windrow traps sediment as it erodes from fill slope.

470 ADMINISTRATIVE PLANNING

Fuel Appraisal

In order for Department prescribed fire planners to develop plans for fuel and fire management projects, knowledge of the vegetative load or fuels is required. Fuel characteristics are incorporated in several state-of-the-art models, which are used to develop estimates of fire potential. Proper planning for prescribed fire practices should, as a minimum, incorporate fuel inventory methods with fuel characteristic information to make the best possible estimates of fire potential. The capability exists to estimate the fuel loading and subsequent fire potential of activity treatments prior to the time the treatment is done.

1. **Fuel Inventory**. Several methods exist which can be utilized to measure or estimate fuel quantity and character. The degree of accuracy required and amount of time available to develop inventory data will dictate which fuel inventory method to use.

    a. Downed Woody Fuel Inventory: Standard inventory procedures are available which tell how to inventory weights, volumes, and depths of downed woody material. These procedures are rapid and easy to use. The inventory of volumes and weights is based on the planar intersect technique, and involves counting intersections of woody fuels on a predetermined number of sample points. USDA Forest Service General Technical Report INT-16, 1974, by James K. Brown entitled "Handbook for Inventorying Downed Woody Material" should be used by DNRC employees who need to do fuel inventories. In addition, a slide/tape series on Downed Woody Fuel Inventory is available for training.

    b. Photo Series: Photo guides have been developed which can be used to appraise the dead woody debris on the forest floor for all major timber types in Montana. These guides are primarily for natural fuels, although some of the photos include old logging and thinning slash. The guides are designed to help forest managers describe the deadwood on the forest floor, estimate the amount of such material, and evaluate its fire hazard. Fuel appraisals obtained from these guides can be used to plan fire management strategies including fire prevention, fuel treatment, prescribed fire, etc. The photos provide a relatively quick and inexpensive aid for accomplishing fuel appraisal. The precision of this procedure is less than the standard fuel inventory but greater than designating a stylized fuel model as is used in the National Fire Danger Rating System.

2. **Stylized Fuel Models**. Fire behavior potential can be determined by using stylized fuel/fire behavior models that are a quick and easy means to predict average fire behavior characteristics of like stands. Selection of an appropriate fuel model, weather conditions, and unit characteristics are required to produce fire behavior predictions. Grass, shrub, timber, and slash models are available from which fire planners can choose a representative fuel model that best represents the existing fuel loading. In the stylized fuel models fuel loadings have been predetermined. Although the 13 FBA (Fire Behavior Analyst) fuel models were originally developed for wildfire suppression purposes, their use in prescribed fire practices is appropriate. The fire manager utilizing the fuel models must be properly trained in the use and application of the output from these models.

Administrative Controls

Orderly progression of logging operations must be scheduled and administered with the total land management objectives in mind. This must be done not only within a single sale but also as one sale relates to another within a given area. It may be beneficial that the sale planner and administrator consult with the appropriate Department fire technician or specialist in order to analyze fire hazards and potential fire behavior and have them in mind when laying out cutting units and administering logging activities. Fire technicians and specialists are available to work with the planner to solve special fuel-treatment problems. It is also imperative that the planner of FI projects such as thinning, be aware of the fuel hazard created and include reduction or protection methods into plans prior to the beginning of on-the-ground operations. The planner may need to modify the scope of the project based on the volume of slash to be created and on the advice of the fire technician or specialist.

475 FIRE BEHAVIOR PRINCIPLES

Factors that influence fire behavior are most commonly expressed in terms of three principal elements: fuels, weather, and topography.

Fuels

Slash fuels burn best when cured. Curing is characterized by low moisture content, which causes fine fuels to be dry and brittle. If trees are allowed to remain on site too long after cutting, the needles and fine twigs fall to the ground. Within a very few years only large stems and branches remain above the duff. Fuels that are either too green or too old may be difficult to ignite, burn poorly, and may not generate enough heat to accomplish the desired objectives unless they are burned under severe fire weather conditions.

Hazard reduction goals can be more fully realized if slash is burned as soon as the fine fuels are adequately cured. When exposed to the sun in midsummer, small (½" and less) logging slash may dry to 10 percent of its original moisture content in two to three weeks. Fully shaded slash generally takes 6 or more weeks to dry to the same extent.

Broadcast burning is more effective when needles are still attached to the slash. The optimum time for burning is within one or two years of harvest. Piled and windrowed slash can be successfully burned over a greater range of conditions than slash prepared for broadcast burning. Consequently, the period available for burning is longer. Greater fuel moisture content can be tolerated in closely arranged fuel elements, although high heat is required for ignition.

Fuel Moisture

Fuel moisture has a critical influence on ignition, flame propagation, and fire intensity. Light fuels such as cured needles and small branchwood take on and give up moisture much more rapidly than larger fuels such as cull logs. (They have lower time-lag moisture contents.) Dormant plants may be sufficiently dry to support combustion, whereas actively growing plants

will resist combustion. Fuel moisture is thus considered in two ways: moisture of dead fuel and live fuel moisture content.

1. Dead Fuel Moisture: The moisture content of dead fuels is usually measured with indicators that correlate moisture with the predominant types of fuel to be burned. These indicators must be located on the site to be burned because local precipitation, humidity, air, wind, and the sun affect them. In dead vegetation moisture occurs as free water (like water in a glass) and bound water. Bound water becomes significant in fuels which have a moisture content of less than 30 percent. More heat is required to remove bound water than to remove free water.

2. Ways of Estimating Moisture Content:

    a. National Fire Danger Rating System. If measurements are taken in the area of the burn, the NFDRS utilizes fuel moisture sticks to represent 10-hour timelag fuels. It also considers 1-hour, 100-hour, and 1000-hour timelag fuels.

    b. Dead fuel moisture and live fuel moisture tables.

    c. Microwave oven.

    d. Moisture meters (require inserting probes into the fuel particle or duff layer).

    e. Microwave moisture meter (gives immediate on-site readout of moisture).

    f. Thermogravimetric moisture analyzer (such as Compu-trac).

    g. Fuel Sticks (½" diameter Ponderosa pine fuel sticks).

    In any moisture determination method (moisture probes, meters, and ovens) care must be taken to ensure that samples are a good representative cross-section of the fuel bed.

3. Live Fuel Moisture: Vegetative condition is usually described as "green," "transitional," or "cured." It may also be described in terms of "days since growth began" or "days since growth stopped." Reference to the season of year and the color of the fuel is also helpful in evaluating vegetative conditions.

Physical Characteristics of Fuel

Volume, size, arrangement, and continuity are important physical characteristics of fuel. The volume of available fuel determines how much heat energy will be released on combustion. Continuity, size, and arrangement influence the rate at which heat energy will be released and affect fire spread characteristics. Other physical characteristics such as texture and cellular structure are also important in determining ignition and fire behavior. For example, punky logs and stumps are easily ignited by embers or radiant heat.

Fuel Chemistry

The chemical constituents of living plants may vary from season to season and affect combustibility. For example, salts being transported in the plant tend to inhibit combustion. Year-long differences in chemical composition are found between species, and possibly even within species growing on different sites. This results in different overall flammability, which may be recognized by an experienced burner.

Certain plant fats and oils volatilize easily and produce combustible gases at relatively low temperatures. In some fuels (such as Douglas-fir needles) the amount of fats and oils increases during the summer. This increase, and the highly combustible nature of the fats and oils, may contribute significantly to the susceptibility of some vegetation to rapidly spreading fires.

Weather

Because prescribed burners should have at their command a thorough knowledge of fire weather, they should be familiar with the works of Schroeder and Buck (1970). Each land office has copies of this publication, entitled "Fire Weather."

However, because airmass circulation, seasonal change, and the interaction of such local factors as wind, humidity, temperature, and precipitation are so complex, the prescribed burner should not rely solely on his knowledge of these factors, but should seek assistance from fire weather meteorologists. The fire danger rating system helps bring together these weather elements. Individual weather elements can thus be integrated with fuel moisture for practical application to prescribed burning.

1. Weather Elements and Interpretation of Weather Forecasts: Forecasts tell the prescribed burner what weather conditions to expect. The subsections which follow discuss the influence of important forecast elements. It must be kept in mind they interact with other elements and are not an entity in themselves.

    a. ***Wind***: Wind is generally regarded as the single most troublesome element of weather. More fires have escaped control due to wind (either during or after the burn) than due to any other factor. Wind is not easy to predict locally, particularly in the mountain-valley topography of western Montana and other mountainous terrain. In spite of these difficulties, wind may have an important beneficial role in prescribed burning. Wind permits the burning of fuel with a relatively high moisture content and disperses smoke so as to maintain air quality. It is also essential to flame propagation in sparse fuels. Burning prescriptions should specify the maximum windspeed tolerable, which is consistent with such factors as humidity, fuels, fuel moisture, slope, and temperature. For prescribed burning under standing timber, windspeeds sufficient to hold back the spread of fire or to disperse unwanted heat may be necessary. NEVER BURN when weather fronts are approaching. Use extreme caution; when scattered thunderstorms are expected, or when high temperatures may coincide with "fresh" (14-20 mph) gradient winds. If a cold front approaches a prescribed fire before it is safely controlled, prepare for strong, erratic winds. Similarly, downdrafts from thunderheads can cause strong, gusty winds to blow from all directions in relation

to the location of the thunderhead. In the daytime, high temperatures will generally cause strong upslope winds which may become stronger and erratic when they are supported by normal gradient winds. Experience has proven that even with extended favorable forecasts, the burn should be in a condition to handle a cold frontal passage at the end of 3 days.

b. Relative Humidity: Relative humidity is an expression of the amount of moisture in the air as compared with the amount it could contain at the same temperature and pressure. Because the moisture holding capacity of air changes with pressure and temperature, relative humidity tables are provided for each of five different elevational ranges. It is important to use the proper table when computing relative humidity.

The moisture in fuels is constantly seeking equilibrium with the moisture in the atmosphere. Dry fuels gain moisture from humid air, while moist fuels lose their moisture to dry air. Fine fuels such as cured grass will respond within minutes to differences in relative humidity, while large fuels may take days. For this reason, 1/2" fuel moisture sticks should be positioned on site about 2 weeks before the burn so meaningful readings can be obtained. For prescribed burning, it is not necessary to prepare a fuel bed as is done in setting up a fire weather station. Satisfactory results are obtained by hanging the sticks in the upper layer of slash in the sun or in open areas in the slash. Locations should be chosen at random and flagged so the sticks can be easily found. Don't place the sticks close to a road where they might collect dust. The main criterion is to place the sticks in a convenient location where the condition of the slash is representative of the unit.

General humidity classes can be used to describe different natural fuel burning conditions.

1) Slow burning conditions - RH above 40%
2) Moderate burning conditions - 26 to 40%
3) Dangerous burning conditions - 15 to 25%
4) Critical burning conditions - below 15%

Recognition of burning conditions should be tempered by good judgment coupled with basic knowledge and experience. Moderate burning conditions have occurred at 80% humidity when water was not bound after a recent rain. Lodgepole has been known to carry crown fire at 17% humidity.

c. ***Temperature***: High temperatures increase fire intensity and likelihood of erratic fire behavior by preheating fuels, lowering humidity, and causing unstable air due to ground heating.

d. ***Atmospheric Stability***: Atmospheric stability has special significance among the weather phenomena affecting fire behavior. Very stable air results when temperatures aloft are higher than those closer to the ground, a temperature inversion. Inversions restrict the dissipation of smoke and heat. Some temperature

inversions are very thick, such as those we experience in the fall during the "smoke management season." Others may be less than a few hundred feet from top to bottom. Very unstable air (when the temperature aloft is lower allowing the smoke to rise on its own accord) promotes convection columns of great height which act like chimneys for the fire below. Unstable air also promotes the development of fire whirls and other erratic fire behavior.

Not all forecasts include indications of atmospheric stability, but forecasters will provide information concerning stability on request. Bumpy flying, good visibility, and the formation of small cumulus clouds early in the morning (especially alto cumulus castellanus) are common indicators of instability. Layered clouds and smoke lying in valleys are signs of stability at least in the immediate area. Unstable air aids smoke dispersal but may increase the risk of fires escaping.

One of the major constraints on the amount of prescribed burning to be accomplished each season is the pattern and frequency of occurrence of desirable burning conditions. Programs RXWTHR and RXBURN are operational tools that make this information available.

e. Fire Weather Forecasting: The National Weather Service stations fire weather forecasters in Missoula and Billings. They will furnish special spot "forecasts" for prescribed burns. Spot forecasts should be requested on form WS-D1 which furnishes the forecaster with on-site information. Keep in mind that forecasts are developed from present weather patterns and expected changes. Because these forecasts are for localized areas, the most complete, accurate, consistent, and localized information is needed to improve the accuracy of forecasts. Often estimates from the area to be burned are of more value than absolute readings from some distant valley bottom weather station. Every effort should be made to obtain accurate readings. The remarks column should be used to describe weather sequence, primarily the wind pattern, for the last 24 hours. Information such as "downslope winds developed last night" or "winds checked were upslope during day with gusty winds over saddles, strong down canyon after sundown" is helpful to the forecaster. Due to the importance and emphasis on smoke management, remarks should include information on inversions, or action of smoke columns in the vicinity. Spot forecasts should be verified by reporting actual weather conditions. Any conditions experienced on a prescribed fire that were significantly different from the forecast should be reported to the fire weather forecaster. This will aid him especially when further burning is to be done in the general vicinity. On-site weather observations should be made on the day preceding the burning operation to obtain reliable forecasts and to determine if conditions are within prescribed limits. On-site weather observations may be taken several days preceding the burn at the time of day when the burning is planned for. To determine local weather patterns, take readings during the hottest and driest time of day and additional wind direction and speed readings at the time of the planned burn.

Portable weather shelters or Climatronics stations are desirable for on-site observations. Satisfactory readings can also be obtained with the instruments in a belt weather kit. RAWS (Remote Automatic Weather Station) data may be available from cooperator stations in some areas.

Topography

Topography affects the way fires behave. Key elements of topography are aspect, steepness, and position from valley to ridgetop. These elements shape the airflow at the burning site.

Aspect

Aspect influences air temperature, exposure to wind, fuel temperature, fuel moisture, and fuel types. The relative fire danger increases from north to south exposure, with the most severe microclimates generally on southerly and southwesterly aspects.

Position on Slope

Fires low on slopes may be influenced by upslope or downslope winds more than fires burning high on the slope. Conversely, fires high on the slope are usually more affected by gradient winds, and fires on the lee sides of ridges are subject to erratic winds caused by eddies.

Morning or evening wind shifts will often begin low on a slope as a result of shading of nearby slopes. During this same changeover period winds at midslope may alternately blow up and downslope, or remain calm.

In mountainous terrain, unusually high fire danger is often found at midslope unless strong gradient winds prevail. At night this midslope zone, called the "thermal belt," is characterized by warm temperatures and only slight humidity increases; thus, fires may continue to burn vigorously late into the night.

Fires spreading up steep slopes without crosswinds will form a triangle with the apex toward the top of the slope. Convective preheating of fuels, lean of flame, radiation, and spotting all contribute to this shape.

Steepness of Slope

Steepness of slope has an effect on fire spread similar to that of wind speed. Fire behavior prediction methods can be used to predict rates of spread based on on-site observations of fuel model and slope.

Shaping of Airflow

The primary topographic features that shape airflow are canyons, saddles, ridges, basins, and benches. The more restricted these passages are, the greater the wind speed and the more likely it is the deflections will form eddies. Gusty, turbulent flows and marked changes in direction are common at intersections of canyons. Narrow canyons should not be used as control lines because of these airflow factors, and because radiant heat increases the likelihood of fires igniting on the opposite side.

480 PRESCRIBED FIRE PLANNING

Fire Behavior Prediction Systems

Several tools are available which will aid the prescribed fire planner in planning for burning operations. The art of fire behavior prediction has made rapid advances in recent years, and as a result new and advanced capabilities and methods are becoming available each year. The Fire & Aviation Management Bureau has attempted to keep the Forestry Division staff and field offices abreast of each new development in processes, software, processors, and publications and reference material relating to these new developments. DNRC land offices each have the most up-to-date hardware, software and related materials available. The job, then, is to utilize these tools to the fullest extent possible. The prescribed fire planning process requires an in-depth knowledge of fire behavior, fuel management, and the integrating effects of fuels, weather, and topography. With the aid of the tools available, the planning is now much less time consuming than it was just a few years ago. It is not less technically sophisticated, but it is less time consuming.

1. **S-190, S-290, S-390, S-490 and S-590**. These five training courses are the core training courses in fire behavior. Trainees receive the most up-to-date knowledge and information relating to fire behavior prediction and planning, both processes and technical information. S-590 will remain a national course taught on odd-numbered years. This course is designed to train the Fire Behavior Analyst in the specialized skills needed to function on an Incident Management Team. Although primarily a suppression-related course, the material taught at S-590 can be of value in the prescribed fire planning area as well. S-490 stresses the understanding of the assumptions, limitations, and appropriate uses of Fire Behavior Prediction Models. It further teaches the student an understanding of how to compute Fire Behavior parameters using advanced techniques to define model inputs and to compute outputs.

   DNRC employees with responsibilities in fuels/fire management should, as a minimum, complete training courses S-190, S-290, S-390, and S-490 (when available).

2. **BEHAVE**. The BEHAVE fire behavior prediction and fuel modeling system is a set of interactive, "user friendly" computer programs. It is a flexible system that can be adapted to a variety of specific wildland fire management needs. BEHAVE is ideally suited to real-time predictions of the behavior of wildfires. It can be used effectively for training and initial attack dispatch. With proper care, it can be used for prescribed fire planning.

BEHAVE draws state-of-the-art fire behavior prediction into one package. Many of the mathematical prediction models in BEHAVE have been available for application in the form of tables, graphs, nomograms, handheld calculator programs, and computer programs. BEHAVE also offers the user the option of designing custom fuel models.

The BURN subsystem of BEHAVE is used for making fire behavior predictions. All DNRC land offices have the capability to do fire behavior prediction through the "PC\BEHAVE Fire Behavior Prediction System for Microcomputers," which we purchased from Microfire. Remember that "PC\BEHAVE" is copyrighted and may only be duplicated for use within your land office organization. PC\BEHAVE is completely menu-driven and is extremely "user friendly." DNRC fire/fuel planners should have no trouble using this software for fire prediction and prescribed fire planning.

3. R_XWTHR and R_XBURN: These two computer programs allow fire managers to quickly and easily analyze climatological data for the purpose of predicting the probable occurrence of desired conditions for prescribed fire.

   Program R_XWTHR offers a method of summarizing local AFFIRMS fire weather observations, fuel moistures, and NFDRS indices from the National Fire Weather Data Library. Output includes simple one-way summaries for 10-day and monthly periods and two-way and three-way co-occurrence tables of user-specified weather variables.

   Program R_XBURN offers a method of determining the timing, occurrence frequency, and persistence of user-specified weather conditions. It is especially useful in planning prescribed fires or identifying periods of historically high fire danger.

   DNRC employees requiring use of either of these programs should complete the user information sheet(s) and submit them to the Fire & Aviation Management Bureau staff specialist for processing. Output will normally be returned to you within one week.

485 PRESCRIBED FIRE TRAINING

Several prescribed fire and related training courses are available to Department employees. DNRC fire/fuel specialists should make every attempt to apply for and complete the courses available. In addition to the existing suppression-related courses, training is available in Prescribed Fire Management, Managing Fire Effects, Fuels Management, Fire Behavior Prediction, Advanced Fire Management (FBA), Fire and Resource Management, and Air Quality/Smoke Management. DNRC employees should watch for fire/fuels management-related symposiums that are conducted from time to time. These symposiums present an excellent opportunity to keep abreast of the current thought, direction and developments in this field.

Each employee with responsibilities in Fire Management should acquire as much training as is available commensurate with the positions to which the employee would expect to be assigned. Obtaining as much training as is required for your position is your responsibility. Completion of every training course available will not make an employee an instant expert. Formal training coupled with on-the-ground experience over time is necessary to become proficient at this

specialized, complex job. Obtaining as much experience as possible is just as important as obtaining as much formal training as would be required.

APPENDICES:

FORMS