# YELLOWSTONE NATIONAL PARK

# STRUCTURE PROTECTION AND FIREFIGHTER SAFETY

# HAZARD FUELS MANAGEMENT GUIDELINES

***An addendum to the Yellowstone National Park Fire Management Plan***

Approved by:

_____Date_____
Michael V. Finley
Superintendent

## INTRODUCTION

Yellowstone National Park contains many unique wonders, among which are significant historic structures. Yellowstone has more than 550 structures eligible for or listed on the National Register of Historic Places. Five of these structures are designated National Historic Landmarks. In addition, there are hundreds of structures that have not yet been evaluated for eligibility to the National Register. While some historic structures, such as backcountry patrol cabins, are located outside of developed areas, the majority of historic structures are located within the park's six historic districts. These districts are located within the existing developed area of the park, which are designated wildland fire suppression zones.

There are 12 major developed areas and numerous minor developments in Yellowstone. The construction of permanent structures in the forest ecosystem has changed the character of these areas from wilderness to a mixed interface of natural and cultural elements. This change requires the National Park Service (NPS) to protect both structures and human life from the threat of wildland fire while at the same time recognizing fire's role in the surrounding ecosystem. The situation creates a further paradox. While the removal of trees can be considered a "taking" by the state, losing structures to fire because no fuels management measures were taken could be interpreted as a negligent adverse cultural impact, resulting from failure to act. This program is a compromise effort to deal with these situations.

The Hazard Fuels Management Plan is an appendix of Yellowstone's Wildland Fire Management Plan and as such is covered by the environmental assessment conducted to write the fire management plan. It addresses the threat of wildland fire entering the developed areas, both frontcountry developments and backcountry administrative sites (cabin areas). The goals of this plan are to enhance visitor, resident, and firefighter safety and to protect structures through a proactive program of fuels management.

The plan makes recommendations for the modification of vegetative landscapes in proximity to existing developed areas in order to reduce the threat to these areas posed by wildland fires. It's based upon the premise that a planned fuels reduction program executed when wildfire is not present is preferable to a "crash" effort implemented ahead of an encroaching wildfire. And further that a hazardous fuels reduction program implemented by park personnel incorporating approved guidelines is superior to that of an incident management team using hotshot or type II crews selected on the spur of the moment. The process used to determine the order in which areas are treated is based upon site visits to determine fuel loading and other pertinent characteristics as well as consulting aerial photos and GIS data to verify field observations.

## FIRE MANAGEMENT POLICY

### Agency Policy

National Park Service management policy directs each park to prepare a wildland fire management plan that is appropriate for that park's purpose and resources. Fire management in Yellowstone is based upon the park's approved Wildland Fire Management Plan (1992) and the Service's Wildland Fire Management Guideline RM-18 (1999). This guideline identifies fire as the most aggressive natural resources management tool employed by the NPS. The guideline also states that fires that ignite in wildland areas will be classified as either wildland fires or prescribed fires. Management response to wildfire will be appropriate to the situation. Prescribed fires are authorized by approved fire management plans.

RM-18 identifies four primary considerations that should be addressed by each park's wildland fire management program. They are:

- Protection of human life, both employee and public
- Protection of facilities and cultural resources
- Perpetuation of natural resources and their associated processes.
- Perpetuation of cultural and historic scenes

### Park Policy

Yellowstone National Park further interprets RM-18 through its Master Plan (1974), Statement For Management (1991), Resource Management Plan (1995), Wildland Fire Management Plan (1992), and other approved documents. Specifically, these documents state the park's objectives For wildland fire management which are:

- To protect human life, property, and designated resources, both natural and cultural
- To allow fire to play its ecological role in the park to the greatest extent possible through the use of appropriate management techniques
- To suppress wildfires in a safe, cost-effective, and environmentally sensitive manner commensurate with the values at risk
- To maintain an active fire-prevention program
- To maintain a qualified fire management staff to implement the fire management plan
- To maintain an interpretive and public information program that will educate the public on the ecological role of fire in the park and provide daily fire danger and situation information.

## HAZARD FUELS DETERMINATION AND REASONS FOR FUEL REDUCTION

Hazard fuels consist of live and dead, burnable plant materials that foster or promote the ignition, spread, or increase in intensity of a wildland fire that would threaten the safety of people or property. A fire that approaches a developed area within the forested environment could be carried by the surrounding fuels into the development, threatening both lives and property. Hazardous fuels management facilitates the natural fire program by creating a defensible space around developed areas that would otherwise be impacted by encroaching fire, thus reducing needed suppression activities or implementing a suppression strategy on the fire. In addition it provides the opportunity for firefighters to safely apply protection measures to structures.

Through proper fuels management, the threat of wildland fire to developed areas can be reduced. Hazard fuels reduction activities focus on the amount and continuity of available fuels. Pruning, thinning, and removal or rearrangement of ladder fuels eliminates the vertical continuity of the fuel arrangement thus reducing the likelihood of crown fire (Figure 1). Removal or reduction of surface fuels eliminates the horizontal continuity of the fuels arrangement and reduces the probability of spot fire ignition, fireline intensity, and rate of spread.

The intensity of wildland fires that threaten developed areas can also be lowered to a level that is acceptable for applying accepted wildland fire suppression tactics. By reducing the amount and continuity of the fuels available for burning, flame length, fireline intensity, and the potential for extreme fire behavior are diminished. Fuel reduction alone can significantly mitigate the threat of wildland fire and make it easier to contain or suppress fires regardless of the fuel type. As illustrated in Figure 2, the use of hand crews is not safe or practical when flame lengths exceed 4 feet. At flame lengths greater than 6 feet, engine and heavy equipment use is no longer safe or effective, and at flame lengths of 11 feet or more, all suppression techniques become risky and largely ineffective. It is not uncommon in the timber fuel types found in Yellowstone to have crown fire flame lengths exceeding 100 feet, with 50 feet being roughly the norm.

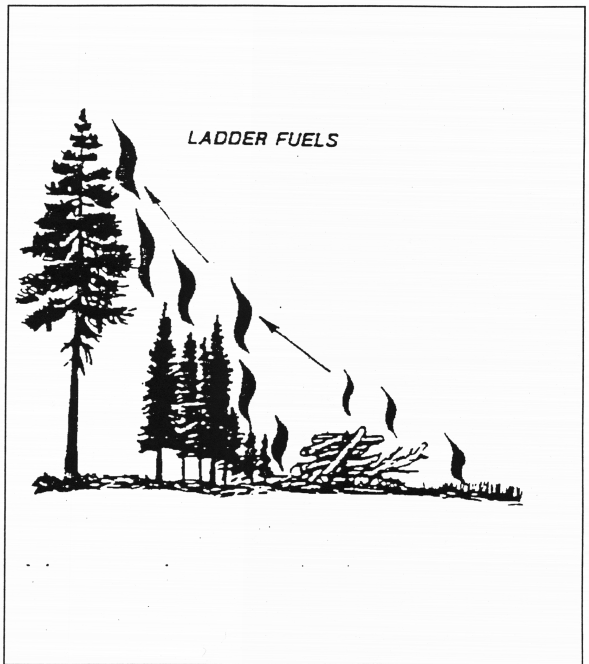


**Figure .** Breaking the vertical continuity by removing one or more layers in the "fuel ladder" typical of mixed conifer forests reduces the likelyhood of a crown fire

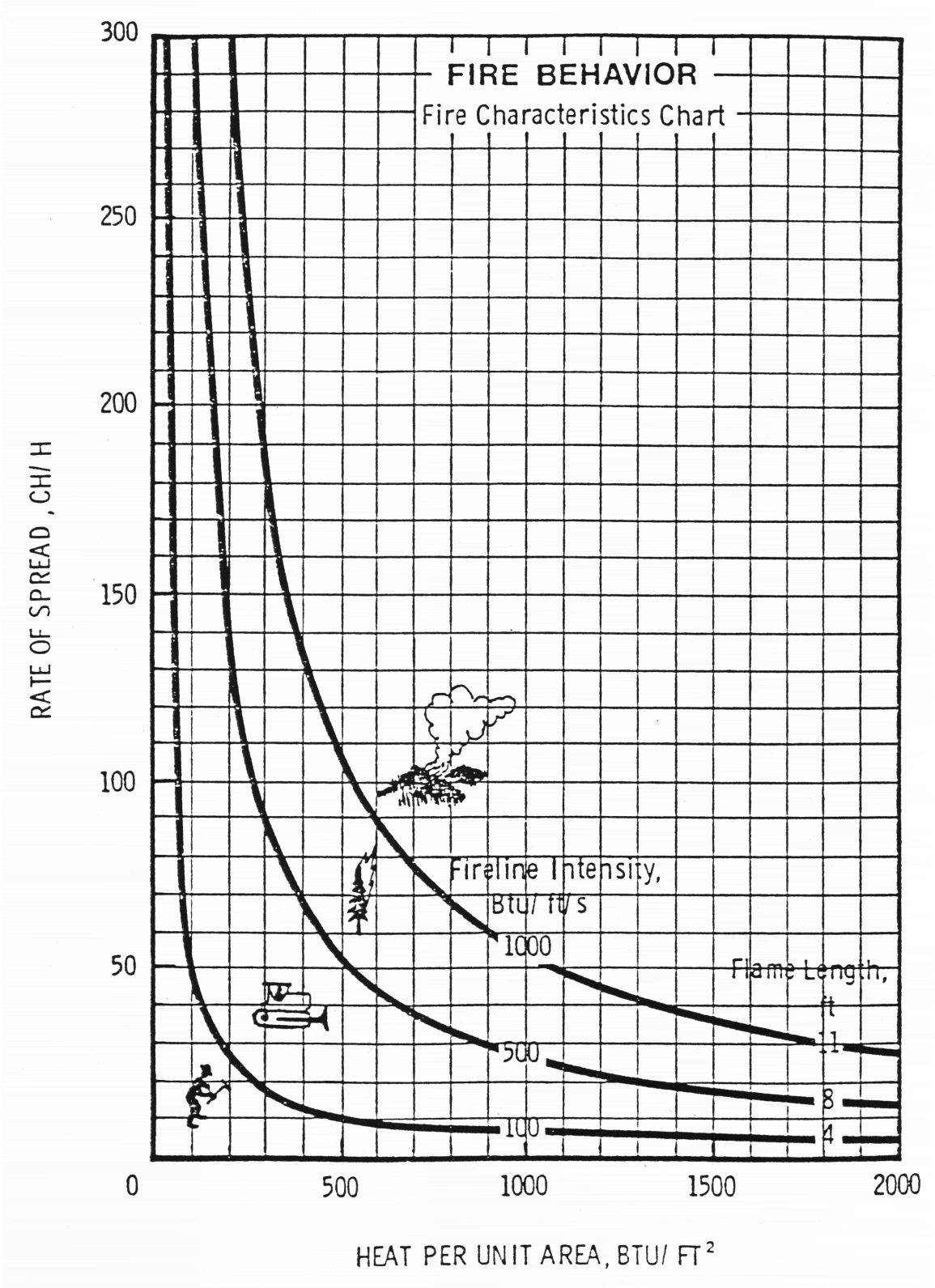
FIRE BEHAVIOR
Fire Characteristics Chart
RATE OF SPREAD, CH/H
HEAT PER UNIT AREA, BTU/FT²
300
250
200
150
100
50
0
500
1000
1500
2000
Fireline Intensity, Btu/ft/s
1000
500
100
Flame Length, ft
11
8
4

Figure 2

Due to safety concerns as well as competition among incidents for suppression resources, complete protection of Yellowstone's developments from wildfire relying only on technology and suppression resources is extremely difficult and impractical. Consequently, the Hazard Fuels Management Program is needed for protecting developments while preserving area aesthetics and recognizing other resource concerns.

**PLANNING**

An integrated approach will be taken to plan each site treatment description. Since the treatment is not site disturbing in intent or practice, National Environmental Policy Act (NEPA) compliance and compliance with section 106 of the National Historic Preservation Act have been achieved via the environmental assessment completed for the parent document, *The Yellowstone NP Fire Management Plan.* However in an effort to achieve an added degree of sensitivity, the following process will be implemented.

1. A structural protection assessment will be undertaken to ensure that fuels reduction is in fact needed and is integrated into an overall protection plan for each site (Appendix I).
2. An archival search will be conducted and a report written to seek out any previously unknown artifacts or historic structures that could be impacted by the project.
3. The project leader will examine the treatment area for any artifacts or sites that have possible historic significance and could be impacted by the project. Those sites will be photographed and reported to an archeologist for further examination. All activities will be halted during this process.

No determination of Eligibility will be completed on the structure to be protected. There is no intent on the part of the Fire Management Staff to modify any structure as part of this process. In addition, by the very fact that hazard fuels management is being implemented, the Fire Management organization is recognizing the significance of the structure.

The affiliated tribes will be apprised of the program as a courtesy and acknowledgement of the role of Native Americans in the cultural heritage of Yellowstone National Park.

## DEVELOPMENT OF TREATMENT PRESCRIPTIONS

Treatment prescriptions are an effort to balance conflicting objectives and are based upon a structural protection needs assessment. While the result of hazardous fuel reduction is meant to make the area less "fire friendly" for several decades, it does not need to leave the area denuded or "cut-over". Initially, following treatment, a developed area will appear more groomed with the trees being more uniformly spaced. However over time, windthrow, regeneration and the accumulation of other forest debris will result in a less managed appearance.

The process used in developing treatment prescriptions for developed areas consists of two parts. The first is to ensure that conditions do not exist that are conducive to the most extreme form of fire behavior, the independent running crown fire. The second relies on the use of fuel models to describe the current and future desired forest condition. While fuel loading described in tons per acre is a common descriptor for a variety of fire calculations such as rate of spread and flame length, it is not a component per se in calculating the potential for a running crown fire. Nor is it used in the Fire Behavior Fuel Model Key or Fire Behavior Fuel Model Description, therefore it is not a direct factor in determining the treatment prescription and is not listed as a key characteristic of the fuel models in question.

An independent, running crown fire is a fire that literally travels through the tree canopy without the need for ground fuels to spread the fire. For this condition to occur, tree crowns must be closer than 20 feet apart and winds must generally be 20 mph or greater. In addition, thousand-hour fuel moistures must be less than 19% and relative humidities must be less than 30%. During peak fire seasons (occurring one to three times per decade), these are the normal conditions in and around forested areas that are typically found in proximity to the developed areas of Yellowstone.

While it can be argued that the firefighters could be expected to apply structural protection measures (e.g., sprinklers, foam, shelter wrap) and then leave in advance of an approaching crown fire, this is not a safe or effective suppression strategy. Firebrand showers in advance of the flaming front, not radiant heat, actually cause most structure ignitions. The ability to combat this threat will depend on the use of some staged suppression resources such as fire engines and firefighters. Therefore, the development must be treated as a safety zone, and, by definition, a safety zone is an area free of levels of radiant heat energy that could harm an unprotected human.

The remedy for this condition is to ensure that tree crowns are not generally within 20 feet of one another and that ladder fuels are sufficiently thin to ensure that conditions do not exist such that ground fire can easily make the transition to the tree canopy. It is extremely difficult for fire to leap from canopy to canopy with such a spacing. The resultant condition is referred to as a shaded or sheltered fuel break. In most Yellowstone situations, 400 feet is the baseline treatment distance from the edge of the nearest building for all prescriptions (calculated using radiant heat and flame length data Butler and Cohen, In Press). The 400-foot figure is derived from an input of a 100-foot flame length, which is a high average flame length for Yellowstone fuels. Creating this condition in an aesthetically acceptable manner is as much art as science. For example, it is possible to leave crowns somewhat closer together when the effects of future windthrow are factored in and ladder fuels are essentially nonexistent or when the undergrowth is particularly young. Proper aesthetics are achieved by recognizing the need to conduct repeated partial treatments several years apart rather than attempting to meet all criteria in one treatment.

Fuel models are descriptions of fuel properties that exhibit similar burning characteristics. These characteristics can be quantifiably described and combined with other relevant data in mathematical formulas in order to predict fire behavior or fire danger. The use of fuel models is not independent of the crown fire characteristics and implications previously discussed. Rather it is a complementary, quantitative method of answering the same question, “Can suppression forces safely and successfully defend the threatened structures?”

There are 13 models, each exhibiting a separate set of fire behavior characteristics. In Yellowstone with few exceptions, a single fuel model can describe each developed area. The pre-treatment model is generally fuel model 10, a timber model characterized by heavy ground fuels, closed canopy and high flame lengths. The desired forest condition needed to achieve the stated goals of this plan is represented by a variation of Fuel Model 8. Model 8 is a timber model and is generally characterized by slow-burning ground fires with low flame lengths and few flare-ups. Only under very severe weather conditions involving high temperatures, low humidities, and high winds do the fuels pose hazards. This model is represented by a closed canopy stand with sparse ground fuels. It has the potential of supporting crown fire, consequently, it is desirable to thin the canopy in developed areas more than is represented by this model.

Summary

The key characteristics of fuel model 8 are:

- Rate of spread: 1.6 chains per hour
- Flame length: 1.0 feet

Achieved by creating:

- *A thinned forest consisting of trees that have crown edges no closer than 20 feet*
- *Extending 400 feet from the edge of any building in the development*
- *With carefully managed ladder fuels (regeneration and surface fuels)*

Under these fire behavior conditions, firefighters can safely conduct suppression actions and have a probability of success in protecting structures near 100%.

After developing a treatment prescription, it is necessary to determine the current fuel model, then remove the excess vegetation, both standing and down, in order to attain the desired fuel model. In order to determine levels of treatment and achieve the desired condition for each developed area, each area will be addressed individually. The actual treatment will vary somewhat depending upon the following fire related criteria: surrounding fuel types, amount of surface fuel, crowning potential, predicted potential rates of spread, stand age, spotting potential, slope, aspect, topography and natural barriers to fire present. Non-fire related criteria, such as visual aesthetics, possible impacts to wildlife, size of the development, and cultural and historic values within or near the proposed treatment area, will also be considered.

**OPERATIONS**

- All work performed under the Hazard Fuels Management Plan and subsequent site-specific treatment prescriptions will be done by crews supervised or monitored by the Fire Management Operation.

- Operations will be conducted in periodic partial treatments over a number of years rather than as a sole effort.

- Resource sensitivity including aesthetics will be considered in all prescriptions.

- The borders of treatment areas will be feathered in an irregular pattern and of increasing fuel density (with distance from the development) in order to improve the visual quality of the border areas.

- During the thinning operation, clumps of trees can be left for aesthetic purposes, depending upon their potential to contribute to adverse fire behavior. Irregular spacing of trees that are left is encouraged in order to maintain a random appearance.

- Standing dead, diseased, or insect-infested trees are a safety hazard and should be marked and removed first during any thinning operation unless there is a compelling resource benefit to leaving them. Standing hazards that are to remain will be prominently marked.

- Thinned trees will be removed form the site whenever possible and utilized (see to the section on disposal). The removal of thinned tree boles and their bark will reduce the total ecosystem nitrogen by less than 5% (Miller et al., 1976). Remaining material should be piled and burned on site or hauled to an acceptable location and burned. Due to the volume produced and the dangerous nature of the equipment involved, chipping is discouraged.

- Dead and downed material to be removed will be stacked in small piles and burned or hauled. Broadcast burns may be acceptable in some cases, but there is a risk of excessive mortality in stands of thin-barked species such as lodgepole pine.

- Pruning limbs to a prescribed height is discouraged as it results in an extremely unnatural, “manicured” look. Similar treatment results can be achieved through a slight increase in thinning and a more complete removal or rearrangement of ground fuels.

- On-site burning will be carefully conducted to reduce fire intensity and duration in order to protect underlying soils.

- All stumps from thinned trees will be cut as close to ground level as possible. Stump grinding may be an option in some frontcountry areas.

- Efforts will be made to leave an appropriate species composition that reflects the natural succession of the forest.

- Prescribed fire is an acceptable option for creating or perpetuating the desired forest condition. It can be used in place of, in conjunction with, or subsequent to mechanical treatment. Determining which method or combination is used is depends upon the site characteristics, constraints, and treatment objectives.

Notifications

The Mammoth Fire Cache will notify the Public Affairs Office of any activities with potential public or media interest at least 30 days in advance. Such activities may include, but are not limited to:

- Heli–logging
- Log hauling with tractor-trailers
- Contract timber cutting
- Work in areas where noise levels could adversely affect the visitor experience
- Activities in which an interpretive presence may be desirable

Upon notification, the Public Affairs Office will inform appropriate park staff or will request the Fire Cache to do so. The Public Affairs Office will conduct all public or media notifications.

Biomass Disposal

Disposal of trees can be accomplished by a wide variety of methods. None of the following options is superior to the others. Any one method or combination of methods can be used for a specific project.

- Firewood permits: This is a quick and easy method of disposing of large amounts of wood. The Visitor Services Office manages the program for residential use by residents of the park and the gateway communities. A variation of this method is to ship the wood out of the park at the expense of and for the benefit of another NPS unit. An example is the relationship Yellowstone has developed with Golden Spike National Historic Site in Utah. Golden Spike has an annual need for 110 cords of wood for use as fuel in their historic locomotives. They have contracted with a local timber company to haul logs generated in Yellowstone Park, as they become available.

- Building materials: Hazard trees can be used as parking barricades, posts, corral rails, amphitheater seats, and as replacement logs in historic structures.

- Burning on site: In areas where soil characteristics do not permit skidding or other equipment use, piling and burning of the hazard trees by hand is a viable option.

- Contract for sale: While the NPS does not conduct timber sales, there are occasions, such as during road reconstruction projects, when the trees are removed by a commercial operator. When such work occurs, the contractor is responsible for all facets of the logging operation, and park staff will monitor the project. Resource concerns include, but are not limited to, respect and care of existing regeneration and other vegetation, hazardous materials spills, minimizing skid trails, and using care not to damage remaining trees during skidding operations. Safety is a concern as well.

- Hauling and burning: The wood can be cut into manageable lengths, usually four feet, then loaded into dump trucks using front-end loaders and hauled to the nearest dry dump. Once wood has been handled in such a manner, it is usually so packed with dirt that it cannot be processed further and is burned. This method should not normally be used, especially if there is any need or desire to use the wood in the future. However, if a severe storm leveled the trees in a human-use area (i.e., campground or along a road) and the area had to be reopened immediately, this might be the most viable alternative.

Skidding is an activity that has great potential for unnecessary resource damage. There are several methods that have been used in the past with varying degrees of success. Helicopter logging is the option that results in the least resource damage. Although it is noisy and intrusive on wilderness values, much wood can be transported in a short time with no soil disturbance or damage to trees left in place. In addition, because it is very fast, the intrusiveness is of short duration. It has worked best with dead trees, as they are considerably lighter to lift. At times the Fire Management operation has been willing to conduct these operations at no-cost as training in the use of long-line skills.

Skidding with horse teams has also been done in the past. During wet periods, horse use impacts soil somewhat less than heavy equipment. During dry periods, there seems to be no advantage to this method. Horse operations proceed very slowly, as the horses need to be harnessed and warmed up in the morning, need periodic breathers, and can haul only a small amount of wood at a time. In addition, inexperienced teams need to be trained on the job, a time consuming process. During the 1995 hazard fuels reduction operations, it was found that on the basis of amount of wood moved, horses were as expensive as using a Eurocopter SA 315B Lama helicopter.

Skidding with heavy equipment provides a third option. This option is very cost effective. However, there is a potential for soil damage in wet conditions, and the services of a skilled operator are required to prevent damage to standing trees and regeneration.

Site rehabilitation is a major and integral component of hazard fuels management. Skid trails and must be rehabilitated by replacing soil and organic litter. Any soil disturbance that could lead to erosion must be mitigated.

<u>Operations considerations specific to backcountry areas</u>

- Safety of cabin protection firefighters and firefighters conducting mechanical reduction operations is of the highest priority. Therefore all cabin sites will meet safety zone specifications.

- The vegetation communities involved are a dynamic system that does not reflect the state of the community at the time the structure was built therefore there is no historic or “preferred” vista per se to preserve.

- Aesthetically pleasing backcountry structure settings and hazard fuels management activities

are not mutually exclusive.

- The distance of the treatment boundary from each cabin will be set at 1/8 mile or 660 feet. While fire behavior calculations would not likely indicate a treatment area that large, the generous size ensures a complete survey for the project.

Site treatment priorities

The following is a list of backcountry structures to be evaluated/treated and their pertinent characteristics. Those structures listed in **bold** type are old enough to be considered historic. Those that are underlined have visual impacts from 1988 fuels work yet to be mitigated. The following lists do not consider hazard tree management needs.

It is the intent of the plan to meet final safety zone specifications on Priority I and Priority II areas during the next 10 years.

Priority I areas

Deaf Jim
**Crevice**
**Sportsman Lake**
**South Riverside**
**Buffalo Lake**
Winter Creek
**Daly Creek**
**Mary Mountain**
**Observation Peak**
**Pelican springs**
Cabin Creek
Cove
Three River Junction
**Nez Perce**

The following structures have had hazard fuels operations implemented to some degree. They should be revisited periodically. They are considered Priority II areas.

**Thorofare**
**Trail Creek**
**Fern Lake**
**Heart Lake**
**Fox Creek**
**Buffalo Plateau**
**Harebell**

The following is a list of backcountry structures that have no immediate need for fuels treatment due to their setting or recent fire activity. However it is prudent to include them in the program as future changes in the forest may dictate a fuels management need. They are Priority III projects.

**Cache Creek**
**Cold Creek**
**Lamar Mountain**
**Lower Blacktail**
**Upper Blacktail**
**Hellroaring**
**Fawn Pass**
Union Falls
**Calfee Creek**
Howell Creek
**Lower Slough Cr.**
Outlet
Elk Tongue
**Upper Miller Cr**
**CougarCreek**

The attached Table 1 carries the process a step further by describing the treatment priority areas in terms of fuel loading, then ranking them in order of greatest to lowest fuel load. By using the two lists concurrently, and factoring in the more subjective considerations, it's possible to more logically select the treatment areas for a given year.

The following is a listing of frontcountry treatment priorities. While many of the same selection criteria apply only two categories are required. Priority I areas are those areas that need to be treated periodically and Priority II areas are those that don't need to be treated at all.

Priority I areas

Lake
Madison
Canyon
South Entrance
Bechler
East Entrance
Northeast Entrance
West Yellowstone
Norris
Old Faithful

Priority II areas

Lamar
Gardiner
Mammoth
Tower/Roosevelt
Fishing Bridge

**CONCLUSION**

Hazard fuels management is a necessary manipulation of fuels in proximity to structures in order to ensure the safety of life and property from encroaching fire. Unfortunately developments in Yellowstone are located in fuel types where large, intense fires are typically how the forest regenerates naturally. Thus managers must create options and alternatives to mitigate this hazardous situation. To many, hazardous fuel reduction is an affront to the "light on the land" NPS approach to land management. However, the proper application of fuels management techniques in developed areas will ensure that the natural role of fire in the evolution of the surrounding forest can continue.

Table 1: Fuel load (tons per acre of live and dead fuels less than 3 inches in diameter), by priority grouping, within 31.4 acres (1/8 mile) surrounding backcountry patrol cabins considered for hazard fuels reduction. Data were derived by buffering each cabin to obtain cover/habitat type, converting vegetation type to fire fuel model, and multiplying the acres of fuel model by each respective fuel model input value. Non-combustible fuel types, such as rock and water, are considered in the analysis. Overall fuel load ranking, from highest to lowest, is also given.

| CABIN | FUEL LOAD (TONS/ACRE) | RANK |
|---|---|---|
| *PRIORITY I:* | | |
| Deaf Jim | 135.42 | 14 |
| Crevice | 27.02 | 34 |
| Sportsman Lake | 99.19 | 25 |
| South Riverside | 89.58 | 31 |
| Buffalo Lake | 212.66 | 6 |
| Winter Creek | 125.71 | 16 |
| Daly Creek | 127.19 | 15 |
| Mary Mountain | 111.23 | 20 |
| Observation Peak | 142.25 | 13 |
| Pelican Springs | 186.13 | 8 |
| Cabin Creek | 237.82 | 4 |
| Harebell Creek | 146.14 | 12 |
| *PRIORITY II:* | | |
| Thorofare | 207.64 | 7 |
| Trail Creek | 73.36 | 32 |
| Fern Lake | 146.53 | 11 |
| Heart Lake | 123.63 | 18 |
| Fox Creek | 267.46 | 3 |
| Buffalo Plateau | 182.56 | 9 |
| *PRIORITY III:* | | |
| Cache Creek | 109.35 | 22 |
| Calfe Creek | 109.35 | 22 |
| Upper Miller Creek | 109.35 | 22 |
| Cold Creek | 153.39 | 10 |
| Lamar Mountain | 19.21 | 35 |
| Lower Blacktail | 28.61 | 33 |
| Upper Blacktail | 93.36 | 29 |
| Hellroaring | 124.97 | 17 |
| Fawn Pass | 102.74 | 26 |
| Union Falls | 360.37 | 1 |
| Howell Creek | 101.86 | 25 |
| Lower Slough Creek | 98.98 | 27 |
| Cove | 98.29 | 29 |
| Outlet | 90.77 | 30 |
| Elk Tongue | 225.39 | 5 |
| Cougar Creek | 112.07 | 19 |
| Three Rivers Junction | 275.06 | 2 |

## Bibliography

Anderson, Hal E. 1982. Aids to determining fuel models for estimating fire behavior. USDA Forest Service, Intermountain Research Station, Gen. Tech. Rep. INT-122, Ogden, Utah. 22pp.

Bakken, Stephen. 1994. Conflicts between natural resources and structural protection. The Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems. Panel discussion.

Bradley, Anne, F. Noste, V. Nonan, and William C. Fisher. 1992. Fire ecology of forests and woodlands in eastern Idaho and western Wyoming. USDA Forest Service, Intermountain Research Station, Tech. Rep. INT-290, Ogden, Utah. 48pp.

Brown, James K., Rick D. Oberheu, Cameron M. Johnston. 1982. Handbook for inventorying surface fuels and biomass in the interior west. USDA Forest Service, Intermountain Research Station, Tech. Rep. INT-129, Ogden, Utah. 13pp.

Butler, B.W., and J.D. Cohen. In Press. Firefighter safety zones: a theoretical model. International Journal of Wildland Fire.

_____, and _____. In Press. Firefighter safety zones: how big is big enough. Fire Management Notes.

Cohen, Jack D. 1999. An assessment of the wildland fire threat to homes in the Boundary Waters Canoe Area Wilderness vicinity following the July 4, 1999, blowdown disturbance. USDA Forest Service, Rocky Mountain Experiment Station, Missoula, Montana. 11pp.

_____. 1999. Reducing the threat to homes: where and how much? USDA Forest Service, Rocky Mountain Experiment Station, Missoula, Montana. 12pp.

Despain, D.G. 1991. Yellowstone vegetation: consequences of environment and history in the natural setting. Roberts-Rinehart Press, Inc. New York, New York. 239pp.

Kricher, J.C., and G. Morrison. 1993. Ecology of western forests. Houghton Mifflin Co. New York, New York. 554pp.

Miller, R.E., D.P. Lavender, and C.C. Grier. 1976. Nutrient cycling in the Douglas-fir type: silvicultural implications. Pages 359-390 *In*: Proceedings from 1975 Annual Convention, Society of American Foresters.

Montana Department of State Lands, Forestry Division. Fire protection standards for wildland residential interface development. April 1991. 26pp.

Montana Department of State Lands. Fire risk rating for existing wildland developments in Montana. November 1991. 11pp.

Moore, P. 1981. Protecting residences from wildfires: a guide for homeowners, lawyers and planners. USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Gen. Tech. Rep. PSW-60, Ogden, Utah 43pp.

Morgan, P. 1991. Hazard fuel management plan, Grand Teton National Park, John D. Rockefeller, Jr. Memorial Parkway. Grand Teton National Park, Wyoming. 23pp.

National Park Service. 1988. Management policies. 131pp.

_____. 1991. Natural resources management guideline, NPS-77. 689pp.

_____. 1992. Wildland Fire Management Plan. Yellowstone National Park. 80 pp.

_____. 1995. Resources management plan, Yellowstone National Park. 35pp.

_____. 1997. Vegetation management plan, Yosemite National Park. 211pp.

_____. 1999. Wildland fire management policy guideline, RM-18. 354pp.

National Wildfire Coordinating Group. 1992. Fire behavior field reference guide. 196pp.

_____. 1993. Intermediate wildland fire behavior, Course S-290. 359pp.

Preston, Richard J., Jr. 1976. North American trees. MIT Press. Cambridge, Massachusetts. 399pp.

Wenger, Karl F. 1984. Pages 873-6 *In*: Forestry handbook. Wiley and Sons. New York, New york. 1335pp.

# Appendix I

## SITE/STRUCTURE EVALUATION WORKSHEET

**SITE:** **Lat/Lon:**

**Factors influencing rate of spread:**

Slope _____ Position on slope _____ Aspect _____ Fuel model _____

Fuel continuity _____ Ladder fuels _____

**Remarks:** _____

_____

**Resources:**

Water supply (type and capacity) _____

_____

Equipment on site _____

_____

Available barriers _____

_____

**Access/egress:**

Road (width, grade, condition, bridges, etc.) _____

_____

Trails _____

Airstrip _____

Helispot _____

Boat _____

**Occupancy** (number, type, duration, etc.) _____

_____

**Identified Protection Level:**

1. _____ No protection

2 _____ Handline construction concurrent with threatening fire

. _____
3 Handline and burnout concurrent with threatening fire

. _____
4 Fire shelter or water system protection concurrent with threatening fire

. _____
5 Fugitive retardent drops concurrent with threatening fire

. _____
6 Use of heavy equipment for fireline construction concurrent with threatening fire

. _____
7 Site/Structure/Improvement preatreatment fuels reduction of unnatural fuels prior to

. _____
fire event

a. Fuels reduction
b. Flammable material movement (firewood, fuel, etc.)
c. Change in building materials

**Proposed Tactics:** _____

_____

_____

**Probability of success:**

| | | Flame length | 0-2' | 2-4' | 4-6' | 6-8' | 8'+ |
|---|---|---|---|---|---|---|---|
| Fair | 40%+ | | ____ | ____ | ____ | ____ | ____ |
| Good | 60%+ | | ____ | ____ | ____ | ____ | ____ |
| Excellent | 80%+ | | ____ | ____ | ____ | ____ | ____ |

_____ _____

(draw site map on back; attach other notes or appropriate information)

Roof: construction type/condition

Siding: material/condition

Heat traps: gables/decks/porches/vents

Foundation: type/material/condition

Windows: exposed/covered/type

Overhead lines: power/phone/shutoffs

Underground lines: power/phone/shutoffs

Fuel storage: type/quantity/lines/shutoffs

Outside combustibles: wood piles/fences/yard accumulation:

Septic tank/location:

Position on slope:

Working space - minimum clearance guide:

| **Slope percentage** | **Uphill** | Actual | **Sides** | Actual | **Downhill** | Actual |
|---|---|---|---|---|---|---|
| **Level to 20%** | | **100 ft.** | | 100 ft. | | 100 ft. |
| 21% to 40% | | 150 ft. | ___ | 150 ft. | ___ | 200 ft. |
| 41% to 60% | | 200 ft. | ___ | 200 ft. | ___ | 400 ft. |

Additional comments:

Prepared by:_____ Date: