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# Chapter 9:

# Implications of Fire Management on Cultural Resources

*It is not what you find, but what you find out.*
David Hurst Thomas

Previous chapters in this synthesis have identified the important fuel, weather, and fire relationships associated with damage to cultural resources (CR). They have also identified the types of effects commonly encountered in various fire situations and provided some guidance on how to recognize damages and minimize their occurrence. This chapter describes planning processes and actions that can be used to manage the effects on cultural resources in different fire and fire management situations.

Three reoccurring themes have emerged in this synthesis: the need to identify, evaluate, and mitigate the impacts of fire and fire management activities on cultural resources. The most critical point of this approach is the need to **identify** the values at risk. The previous chapters have provided a clear idea of the scope of cultural resource elements—both tangible and intangible—that could be lost if not properly protected and what may cause the most harmful effects to each. This report has assessed fire's effects on cultural resources of many types, but for fire managers there may still be questions about what is actually at risk. Each resource was discussed in detail, identifying not only its physical properties but also its cultural significance. The values of these resources were identified through field surveys, georeferencing techniques, and consultations with local community members and tribal liaisons (chapter 8).

What determines the value of each element? Through **evaluation**, using the matrix process detailed later in this chapter, we are able to define not only the physical properties or significance of each element but also management and inventory techniques. These evaluations also often provide a context for future desired conditions for the site as well as the priority for comparison to other elements. Specifically, the matrix identifies values at risk versus fire behavior *and* management actions. The *Risk Management* section below and also the *Introduction* (chapter 1) define direct and indirect effects of fire and operational activities on cultural resources. Other chapters allude to operational effects through examples. Simply stated, operational effects are effects on cultural resources caused by fire suppression activities such as digging line, dropping retardant, cutting down trees, or other tactics. In fire management activities, particularly fuel treatments and restorations, the evaluation process involves a number of iterations where expected fuel consumption and fire behavior are evaluated for their potential impacts on CR and prescriptions are modified to minimize adverse effects and the need for subsequent mitigation.

**Mitigation** is the final step in managing cultural resources because it is not possible without identification and evaluation. Careful planning and advance knowledge of the types of cultural resources commonly encountered on a management unit can minimize negative effects to CR. However, new cultural resources are often discovered following fire. If we do not know what is there, we cannot create a means to evaluate what is important to preserve, or plan how to best protect these resources from damage or destruction. Mitigation, in this context, are the preventative measures that both cultural resource specialists and fire managers can use to limit direct and indirect effects of both fire and fire management activities. Mitigation of fire and suppression effects on CR has been discussed in previous chapters and is discussed in the sections below as an essential step for both planned and unplanned fires.

The objective of this chapter is to provide an integrated summary of the potential impacts for fire-related activities within a framework useful for managers. It presents additional information for both cultural resource specialists and fire managers to help them understand the resources they are trying to preserve, how they are damaged, and to create processes to better preserve them.

## Planning

The management of cultural resources is becoming an increasingly important concern for managers of Federal, State, and tribal lands. Numerous laws, regulations, policies, and guidelines that address cultural resource management have been developed over the last 100 years. Section 106 of the National Historic Preservation Act (P.L. 89-665, as amended, P.L. 91-423, P.L. 94-422, P.L.94-458 and P.L. 96-515), along with its regulations (35CFR800), require cultural sites to be evaluated for their potential to be eligible for listing in the National Register of Historic Places. The law also directs Federal agencies to assess the effects of a proposed project on any eligible properties. Past and potential fire impacts to artifacts and features are critical in assessing both eligibility and effects. Managers must, therefore, be able to integrate the application of an existing regulatory framework with the knowledge of potential impacts to these irreplaceable cultural resources.

Effective cultural resource management begins with strong management commitment, good inventory data, solid planning, and effective monitoring. General or land and resource management plans (LRMP) define the mission and strategic direction for a unit of land. These broad-scale plans typically identify the pertinent laws and authorities associated with the creation of the management unit, its geographical location, roles and responsibilities, stakeholders and partners, important laws governing the management of the unit (e.g., in the United States: National Forest Management Act, Federal Land Policy and Management Act, Endangered Species Act, Clean Air Act, Clean Water Act, National Historic Preservation Act, etc.), the resource goals to be promoted by the plan, the values at risk, and the sources of those risks (fig. 9-1). Ideally, LRMPs also clearly describe the types of vegetation, the role of fire regimes, and the historic and prehistoric uses of the land. Similarly, cultural resource management plans (CRMPs) identify the pertinent laws and policies governing the protection of historic and prehistoric heritage resources, roles and responsibilities, and key contacts such as the State Historical Preservation Officer and indiginous community leaders. They also identify the cultural resources (CR) including cultural landscapes; the types of sites; known or probable resources and their location, as appropriate; as well as the threats or risks to the CR. Some sites may be well known (lookouts, ranger stations), while locational information of other sites (prehistoric camp sites) is exempt from public disclosure to protect the resource from vandalism (Christensen and others 1992). CRMPs also identify the state of knowledge and the CR practices and standards for inventorying, monitoring, stabilizing, and restoring resources as well as measures for minimizing and mitigating negative impacts associated with other management activities. Likewise, fire management plans (FMPs) define pertinent laws and policies, authorities and responsibilities, goals, options, and constraints facing fire management. FMPs typically include descriptions of historic role and use of fire in the management unit; elements of the fire environment including vegetation/fuels, terrain influences, and historic fire weather; fire occurrence and behavior; the values at risk; and resources protected. The standard focus of FMPs includes public and fire fighter safety; natural, air, and cultural resources; infrastructure, and wildland urban interface. FMPs describe appropriate actions for fuels treatment, restoration, and wildfire suppression based on current knowledge and practices. Both the cultural resource management plan and the fire management plan provide direction to the LRMP and draw direction from it. All three are part of an integrated approach to effective planning and stewardship of natural and cultural resources. Fire management and cultural resource plans are integrated with land and resource management plans to form the basis for proposed activities. Actual activity plans require interdisciplinary integration of other resources and processes. Assessment of actual

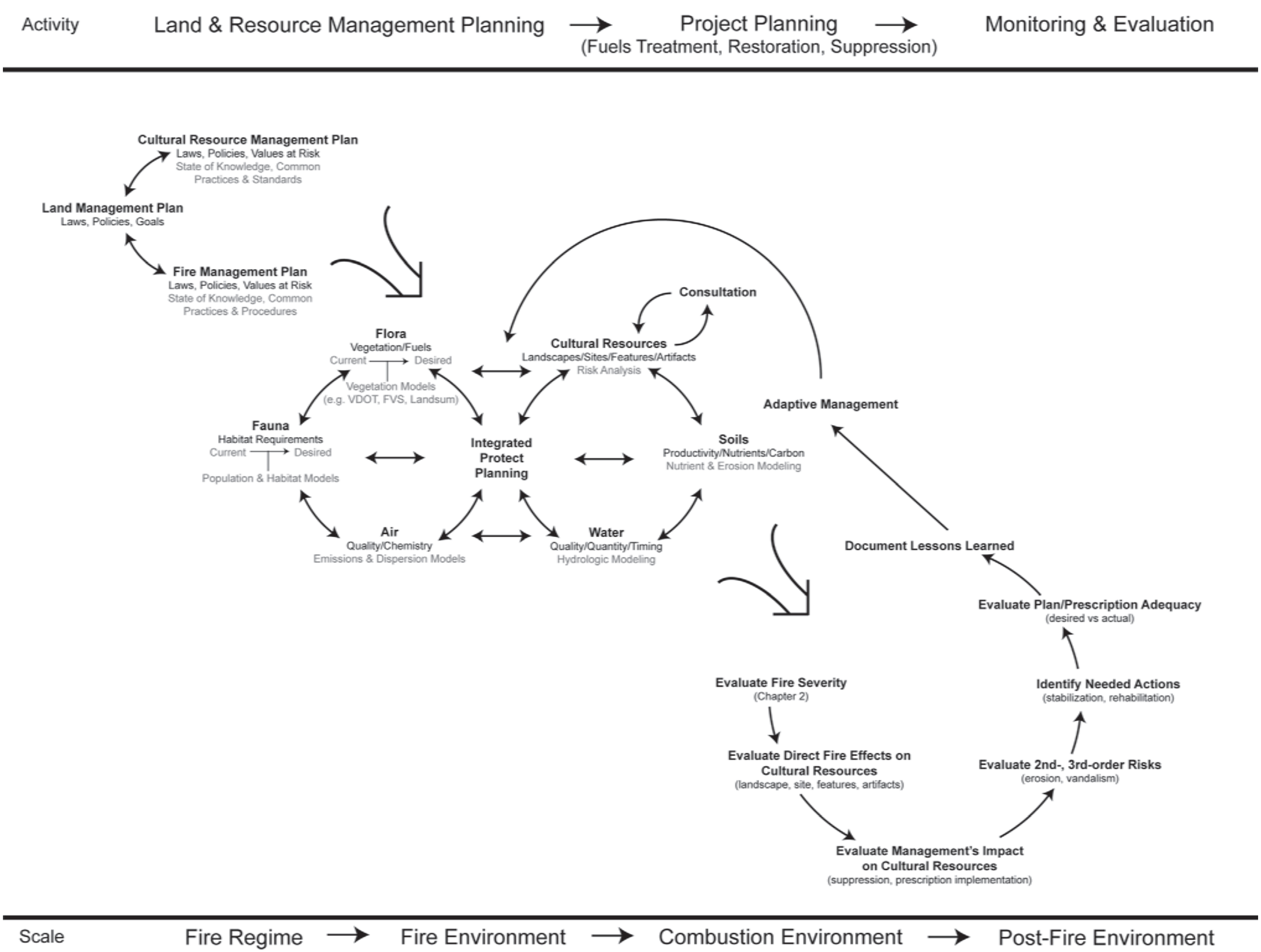


**Figure 9-1**—Schematic of the planning process as it relates to cultural resource (CR) protection.

and potential impacts on CR following action (fire) requires inventorying, monitoring, and interdisciplinary assessment. These support critical evaluation of preexisting plans and procedures, documentation of lessons learned, and refined knowledge in support of adaptive management.

Well written integrated LMPs, CRMPs, and FMPs provide a foundation for designing and implementing projects that achieve their shared-collective goals. Integrated project planning addresses the effects of proposed actions on flora (Brown and Smith 2000; Steffan and others 2010; Zouhar and others 2008), fauna (Engstrom 2010; Smith 2000), air (Sandberg and others 2002), soil and water (Neary and others 2005), cultural resources (chapter 1), communities (Aplet and Wilmer 2006; Daniel and others 2005; Jakes and others 2007; Shlisky and others 2007; Wells 2009), and infrastructure. Integrated project planning involves an iterative process of evaluating trade-offs between competing goals and objectives to arrive at the best alternative for a multiple of resources (fig. 9-1). It is an interdisciplinary collaborative effort involving stakeholders (Jakes 2008; Kaufmann and others 2009; McCaffrey 2006; Sturtevant and Jakes 2008). Fire managers need to consider all significant and sensitive CR and to be proactive to minimize potential damage. Active involvement of CR specialists in the planning and conducting of fire management activities is integral to meeting CR goals and objectives (table 9-1).

Following fire, CR specialists need to evaluate the fire's severity and its impacts on the cultural resources. (Chapter 2 provides guidelines for evaluating fire severity.) Fire's impacts may be the direct result of heating or the deposition of chemicals released during the combustion process (soot, tars, adhesions, etc.). Other chapters in this publication provide guidance on determining the direct effects of fire on ceramics (chapter 3), lithics (chapter 4), rock art (chapter 5), materials of the historical period (chapter 6), and subterranean structures (chapter 7). Evaluation of the effects of fire on CR requires that the CR specialists consider the combustion environment, i.e., the local small-scale environment juxtaposed around each site or artifact as it is at this scale that the direct effects occur (chapter 2).

In addition to evaluating the direct effects of fire on cultural resources, CR specialists need to evaluate the impact of fire management activities (fig. 9-2b) (broken bedrock mortar) and the potential for second- and third-order effects such as the potential for post-fire erosion (Allen 2001; Lesko and others 2002; Johnson 2004; Kelly and Mayberry 1980; Neary and others 2005) and for vandalism (Christensen and others 1992; Davis and others 1992a,b; Downer 1992; Higgins 1992), respectively. Erosion potential is a function of the terrain, geologic parent material, fire severity, and expected post-fire weather, principally precipitation (Neary and others 2005). Effective evaluation of erosion potential and the need for post-fire stabilization and rehabilitation requires an interdisciplinary effort. Following planned (e.g., fuels treatment, restoration, prescribed burning, etc.) and unplanned (e.g., wildfire

**Table 9-1**—Advance planning–preparedness: A U.S. Federal lands example.

| **Proper cultural resource planning is the best way to respond to any planned or unplanned fire. There are several steps that can prepare for making decisions about cultural properties:** |
|---|
| • The Cultural Resource Specialist prepares a GIS layer with locations of known eligible and unevaluated properties, where wildfire management decisions dictate necessary site protection. |
| • The Cultural Resource Specialist prepares a GIS layer based on the likelihood of cultural properties using a predictive site model. In lieu of a GIS layer, the Forest will utilize a hard copy map of site probability. |
| • The Cultural Resource Specialist, in cooperation with a Fire Specialist, prepares Site Protection Plans (SPPs) that identify the appropriate protection measures for various cultural property types. As these plans are developed, they can be provided to the appropriate Historic Preservation Office, either the State Historic Preservation Office (SHPO) or the Tribal Historic Preservation Office (THPO) for their review and comment. |
| • The Cultural Resource Specialist provides instruction during any forest Wildland Fire Decision Support System (WFDSS) training on the Federal laws and Forest Service policies regarding the protection of cultural resources. The training will include the procedures for cultural resources protection. |

suppression) actions, a formal review of the prescriptions, plans, and execution should be conducted. Lessons learned should be formally documented to provide a basis for a formalized adaptive management process that leads to improved management of future projects (fig. 9-1).

## Risk Management

Cultural resource and fire managers should assess potential risks when evaluating the effects of wildland fire, prescribed fire, fire use and fire suppression on cultural properties. These risks include the direct, first order impacts from the fire itself as well as suppression activities, and the indirect effects such as erosion potential (chapters 1 and 2).

Direct effects that occur as a result of the fire itself include the combustion of burnable cultural materials (wood, shells, paints, glazes) and physical and chemical changes in materials (spalling, charring, calcification, crazing, melting, heat and chemical alteration). Direct effects are the result of the physical and chemical processes associated with combustion. In contrast, indirect effects occur as a consequence of the direct effects, and are of two types: human responses and biophysical responses (chapter 1). For example, from April to June, 2007, a series of fires collectively named the Bugaboo Fire burned over 600,000 acres (2,400 km$^2$) in the Okefenokee National Wildlife Refuge, Osceola National Forest, and adjacent lands. Hundreds of miles (kilometers) of fireline were dug by tractor-plow and hand crews, exposing and damaging numerous CR sites and features. Over 100 new sites were discovered on 407 kilometers (253 miles) of fireline on the Osceola National Forest alone (Lydick and Donop 2009). Cultural resources may be affected directly by suppression activities (hand and mechanical fire line construction (figs. 9-2, 9-3), retardant use (Reed and others 2007)

A

B

**Figure 9-2**—Dozer cat line on the 2001 Highway 88 Fire near Ione, California; (A) exposed unknown bedrock mortar; and (B) damaged bedrock mortar (photos by Sharan A. Waechter, Far Western Anthropological Research Group, for CalFire).

A

B

**Figure 9-3**—(A) Fireline on 2007 Bugaboo Fire, Osceola National Forest; (B) Pottery sherds impacted by tractor-plow fireline construction.

and rehabilitation activities. It is generally concluded that fire suppression activities during wildland fires and post-fire site rehabilitation treatments present the most consistent adverse impacts and pose the greatest risk to cultural properties. The indirect effects of fire include exposure of surface cultural properties to erosion and to increased visibility. The removal of vegetation and surface litter can expose cultural properties formerly not readily visible to the eye, therefore making them more vulnerable to looting (Christensen and others 1992). Post-fire erosion on steep slopes of severely burned areas can occur after intense wildland fires have destroyed most of the pre-fire vegetative canopy, causing the horizontal displacement of surface cultural materials (Allen 2001; Johnson 2004; Lesko and others 2002; Timmons and others 1996). A fire can leave standing vegetation that becomes vulnerable to blow down and can impact both surface and subsurface cultural properties.

The elements of risk for adverse impacts to cultural properties can only be assessed in a rather detailed analysis that takes into account multiple factors. One set of factors relates to the type of cultural features and artifacts (elements) involved and the relative location of those cultural properties on the landscape. Often the locations of features or sites are known before hand. Often such CRs are discovered through pretreatment or post disturbance surveys, Usually the types of resources to be expected in an area can be anticipated, (sidebar 9-1), but sometimes new discoveries are made. Another set of factors relates to the interaction of the environment with fire. As the previous chapters describe, not all cultural properties will respond to fire in the same way. How a cultural property will react to fire depends on its material composition (organic/inorganic), its provenience (surface/subsurface), existing fuel loads (grasses/heavy deadfall), fire intensity (high/low), duration of heat, soil heat penetration, and fuel, soil, and duff moistures.

## Sidebar 9-1—Observing and Conserving Cultural Features

Archaeologists become familiar with the types of resources in their particular area: the known sites, common features, types of artifacts, and the raw materials used in their geographic area. When CR specialists are deployed on fire assignments to new areas they need to come up to speed quickly by interacting with local specialists. Wildland fire suppression forces commonly get deployed all around the country where they encounter historic and prehistoric cultural resources. Old buildings, rock art panels, railroad trestles and other highly visible features are easily recognized as such and alert firefighters to the need to take special caution and solicit input from CR specialists. However, many CR are subtle and not easily recognized by the untrained eye. There have been instances where fire crews have "collected" artifacts and a number of examples where CRs were inadvertently damaged. Education and training can minimize these damages. Line scouts and crew bosses need to learn to spot features and minimize potential damage. The following examples illustrate the types of CR one may encounter.

A

**Figure 9S-1a—**Prehistoric hunting blind (photo by Becky Timmons, USFS Kootenai National Forest). The linear structure and stacked-rock nature of this feature identify it as a cultural resource.

B

**Figure 9S-1b—**Archaic stone hearth (note circular pattern of rocks) revealed by forest floor consumption during prescribed burning (photo by Becky Timmons, USFS Kootenai National Forest).

C

**Figure 9S-1c—**A slab-lined basin (prehistoric cooking pit), normally with just the tips of the walls above the surface. Erosion post-fire partially deflated the feature. The 2002 Mustang Fire burned up to the edge of the feature, which is now undergoing further deflating (lower right area in photo) (photo by Clay Johnson, USFS Ashley National Forest).

D

**Figure 9S-1d—**Trash dumps are commonly found in rural locations and may indicate a historic site such as this garbage dump site from a World War II prisoner of war camp near Monticello, Arkansas (photo by Don Bragg, USFS Southern Research Station).

E

**Figure 9S-1e—**Features such as this hand-dug well on an old homesite near Monticello, Arkansas, are easily recognized as man-made. In old mining districts such shafts are also common features that should be avoided for both safety and CR reasons but should alert fire fighters to be aware that other CR may be near-by (photo by Don Bragg, USFS Southern Research Station).

F

**Figure 9S-1f**—This rock circle on the south flank of Grand Mesa in western Colorado was one of three such rock circles on a very low ridge in the pinyon-juniper. Rocks were cleared on this lava rock ridge to make a circular space. An excavation nearby showed occupation going back about 5,000 years. One flake was found in the interior (photo by Sally Crum, USFS Grand Mesa-Uncompahgre National Forest).

G

**Figure 9S-1g**—Overhanging rock shelves such as this overhanging sandstone on the Uncompahgre Plateau rock often formed rock shelters for native people. Care should be taken to minimize soil disturbance without guidance from a CR specialist (photo by Sally Crum, USFS Grand Mesa-Uncompahgre National Forest).

H

**Figure 9S-1h**—Wickiups are common features throughout the western United States. What may at first glance appear to be a random jack-straw of natural fuels may be an archaic hunting camp site (photos by Sally Crum, USFS Grand Mesa-Uncompahgre National Forest).

The previous examples are but a few of the near infinite things fire managers may encounter in the field. The first and foremost rule of fire is safety first. Next comes protecting the resource, including cultural resources. A few simple rules can guide actions:

- If it looks like a good place to camp then someone has likely camped there in the past, perhaps for hundreds of years.
- If there is a majestic view, you are not the first to marvel at it.
- If something looks "out of place" or "unnatural," it may deserve greater scrutiny.

However, non-specialists should not pick up, overturn, dig at, or otherwise disturb suspected CR. Important archaeological information can be lost just by picking up an artifact, even if it is put back down afterward. There is a good chance that he or she is on a previously recorded cultural site, where the artifacts have been recorded and are being monitored; these sites also should not be disturbed. There is also a good chance that the site is previously unrecorded. It is common to find previously unknown CR following a fire. If you find something that looks interesting:

- Leave it right where it is;
- Get a GPS location if possible;
- Take a photograph if possible; and
- Contact the local resource advisor or cultural resource specialist assigned to the fire.

## Wildland Fire Management Recommendations

The protection of cultural resources during wildland fire is more challenging than for a prescribed burn. Treatment options available to mitigate the direct impacts from wildland fire include use of water, retardant, and fire shelter material. Retardant and water drops on sensitive cultural sites are possible; however, the use of retardant has some effects on cultural properties that should be considered (Reed and others 2007) (sidebar 9-2). Some areas can be protected by judicious backfiring operations that are designed to protect designated cultural properties from the direct onslaught of the fire. MIST (Minimum Impact Suppression Techniques) suppression methods can help to minimize suppression activity impacts:

- Cold trail and wet line versus mechanical and hand line construction
- Alternative mechanized equipment (rubber tired skidders versus tracked skidders)
- Minimal scraping and tool scarring during mop-up activities
- No piling of burned and partially burned fuels
- Avoidance of camping in meadows and along streams or lakes, as there is a high probability for buried cultural properties

### Sidebar 9-2—Effects of Fire Retardants on Cultural Resources

Fire retardants, particularly those dropped by aircraft, are an integral tool in fire management. While retardants can be critical to fire suppression success (fig. 9S-2a), they pose a threat to cultural resources (Reed and others 2007) (fig. 9S-2b,c; table 9S-2.1). Retardants are fertilizer-based salts (commonly diammonium phosphate or ammonium sulfate) that contain corrosion inhibitors and, typically, iron oxide, which can be absorbed on porous surfaces leaving long-term staining. The salts can alter moisture relations causing shrinking and swelling that can damage the surface. Phosphates in some retardants can affect archaeological analysis of prehistoric occupation of a site. The fertilizer salts are corrosive to many metals.

A

**Figure 9S-2a**—Aerial view of Mesa Verde National Park Headquarters and retardant drops (reddish area) used to protect cultural resources and park infrastructure.

B

**Figure 9S-2b**—Spruce Tree House, Mesa Verde National Park, illustrating effect of retardant on sandstone cliff-face, note Burned Area Emergency Rehabilitation (erosion mats) to protect cliff dwelling from water and debris coming over the overhanging edge of the alcove.

C

**Figure 9S-2c**—Close up of sandstone wall, showing the coverage of slurry coating. Dried slurry is hard, difficult to remove, long lasting, and accelerates weathering.

**Table 9S-2.1**—Summary of findings on rehabilitation of sites impacted by fire retardant.[a]

<table>
<tr><th colspan="6">Retardant cleaning procedures<br>Begin with least invasive method</th></tr>
<tr><th colspan="3">Recommended</th><th colspan="3">NOT Recommended</th></tr>
<tr><td colspan="3">• Dry brushing<br>• Hand brushing w/ water<br>• Hand brushing w/blkaline surfactants<br>• Poulticing</td><td colspan="3">• Power washing<br>• Sandblasting<br>• Acid based washes</td></tr>
<tr><th colspan="2">Sandstone</th><th colspan="2">Painted wood</th><th colspan="2">Metals, glass</th></tr>
<tr><td colspan="2">• Pre-soak w/ water<br>• 10% borax solution (surfactant)<br>• Gentle circular brushing w/ natural fiber<br>• Rinse w/ water<br>• Repeat where necessary</td><td colspan="2">• Pre-soak w/water<br>• Brushing w/ mild detergent<br>• Rinse</td><td colspan="2">• Wipe or sponge w/ mild detergent<br>• Wipe dry</td></tr>
<tr><th colspan="3">Summary of retardant investigations</th><th colspan="3">Strategies for retardant impacts mitigation</th></tr>
<tr><td colspan="3">• Retardants pose potential risks to health, safety & cultural properties.<br>• Retardants will not wash off naturally; they require intervention to remove, particularly on vertical surfaces<br>• Mitigative measures were tested that effectively removed retardants without further damage to cultural resources</td><td colspan="3">• Assess impact - resource type, retardant type<br>• Research retardant type and MSDS<br>• Evaluate risk to resources<br>• Mitigate impacts where necessary<br>• Map affected areas<br>• Establish monitoring system<br>• Consider integrating potential suppression impacts into Fire Management Plan</td></tr>
</table>

[a] Corbiel, Don. 2002. After the fire: Investigating fire suppression impacts on historic resources. Lessons learned from the Long Mesa Fire of 2002. Washington, DC: U.S. Department of the Interior, Bureau of Land Management. PowerPoint presentation. 59 slides. Online: http://www.blm.gov/heritage/powerpoint/Fire_Corbeil/Impacts%20to%20Historic%20Resources_2_files/frame.htm.

In particular, some suppression tactics should be carefully considered in areas of known cultural properties as they have a greater potential for adverse impacts, such as:

- Use of fire line explosives
- Allowing the burning of trees, snags and stumps
- Repair of soil compaction by scarification

Disturbance by fire suppression activities can be mitigated to some extent by conducting pre-fire cultural resource surveys and careful planning of fire suppression strategies in areas of cultural properties. Fire Management Plans are designed to analyze specific management areas/response zones in order to identify:

- Appropriate management response strategies for each fire management unit or fire management area;
- Acceptable fire suppression tactics;
- Strategic priorities;
- Resource values and suppression cost factors;
- "Must meet" criteria;
- Fire intensity, size, duration, and seasonal constraints;
- Areas/conditions where firefighter safety is compromised;
- Objectives/desired conditions/standards and guides; and
- Risk analysis process and parameters.

It is vital to integrate cultural resource values into these plans by providing management level information about cultural properties. Some general information to include in Fire Management Plans might be:

- Identification of significant cultural resource values at risk on large-scale maps, along with their National Register eligibility status;
- Assessment of risks to cultural properties;
- Options to reduce risks to vulnerable cultural properties, such as reduction of fuel loads, careful construction of fire lines, etc.;
- Benefits and impacts on local cultural properties as outlined in any fire guidelines, such as MIST, that may exist;
- Tribal communications protocol to be used during wildland fire suppression;
- Documentation of known issues as compiled with interested stakeholders;
- Identification of training courses recommended for cultural resource specialists that would prepare them for fire positions such as fire line locators, heavy equipment supervisors, rehabilitation team members, and resource advisors;
- Outlining cultural resource training for site protection issues for fire suppression personnel;

During fire suppression activities, several steps can be taken to further protect significant cultural properties. For example, in the United States when a fire has been declared on Federal land a wildland fire, a Wildland Fire Decision Support System analysis is prepared. This document addresses how specific fire suppression tactics will meet the guidance provided in the Fire Management Plans, including the following recommendations:

- Using any cultural property information available (GIS) to determine the cultural properties within and adjacent to the fire. Identify and map the location of significant cultural properties at risk for field reference. The status of eligibility for each site should be tracked. Traditional cultural properties should also appear on the map, if possible.
- Immediately assigning trained cultural resource specialist to fires where there are known cultural properties so that they can get out ahead of any large equipment.
- Organizing cultural resource specialist teams that are made up of qualified archaeologists and tribal representatives.
- Using the local cultural specialists to advise the archaeologist assigned to the fire if they are not local.
- Considering the location of fire camps to assure that cultural properties are not impacted.
- Including cultural resource information as part of the Wildland Fire Decision Support System.
- Encouraging cultural resource specialists to work with large equipment operators and line scouts.
- Encouraging cultural resource specialists to brief suppression crews and other field personnel.
- Ensuring that cultural resource specialists keep detailed notes on areas covered and cultural properties located and damaged.
- Consulting with State historic preservation offices following the protocol agreed upon.

## Prescribed Fire

Prescribed fire is used to manage both vegetation and fuels for the purpose of restoring ecosystem processes, with several goals in mind: (1) biomass reduction, (2) site preparation for regeneration of conifers and shrubs, (3) rejuvenation of shrubs and grasses, (4) enhancing germination and growth of forbs, and (5) suppression of in-growth species. Prescribed fire may also be used to reduce fuels that could endanger buried cultural resources in the event of a wildland fire.

Prescribed fire severity varies depending on the prescription (such as, whether the fire is intended to be non-lethal, mixed-severity, or stand-replacing; light, moderate, or deep depth of burn). An earlier section of this publication (chapter 2) describes the physical process of combustion, the effect of different severities of burning on damage to vegetation, heat transfer to the soil surface, the subsequent transfer of heat downward into the soil, and potential impacts to cultural resources. It is the combustion process; along with the subsequent generation of heat, that directly damages cultural properties above, on, and below the soil surface. Above-ground materials may be directly consumed or irreversibly altered by the heat produced by the fire. Cultural materials found on the soil surface are exposed and vulnerable. Cultural resources within the soil are less likely to be changed unless heavy accumulations of surface fuels or organic soil are burned. Assessment of risks involved when using prescribed fires includes not only the potential damage of the fire to the cultural material, but also the trade-offs with other resources and the potential for escaped fires.

Cultural properties with heavy fuel loads in the form of coarse woody debris (deadfall, stumps, logging/thinning slash), thick dry duff, and dense standing vegetation may be at risk from prescribed fire. All fuel elements in the fuel bed should be considered for their potential to cause damage. For example, rotten and partially rotten logs easily sustain combustion at moisture contents well above those of solid fuels. In a study of fire in lodgepole pine forests in eastern Oregon, Agee (1981, as cited in Agee 1993) noted that even under moderate fire weather, partially decayed logs (decay class 3-4) can be the primary corridors for fire spread. Even logs with relatively high moistures (40%) will serve as corridors to carry a ground fire. The depth of heat penetration varies with the volume of coarse woody debris, whether combustion is primarily by flaming versus smoldering combustion and soil moisture (chapter 2). Temperatures associated with flaming are often two- to three-hundred degrees higher than those of smoldering, and high soil moisture presents a barrier to high heat penetration (Campbell and others 1994, 1995). In one study research, Agee (1993) found that a log smoldering for 3 hours registered a temperature of 100 °C (212 °F) at the mineral surface while the temperature of the soil under the log at 5 cm (2 in.) was only 50 °C (122 °F).

The most dramatic effects from fire will occur around stumps (sidebar 9-3). Thermocouple measurements confirm high temperatures from burning stumps at 1500 °C (2732 °F) (Traylor and others 1979). In one study Timmons and others (1996) observed burning stumps in the Green Basin Prescribed Burn in northwestern Montana. Stumps that were 30 years old did not burn, but the 45-year-old stumps burned completely. The older/drier the stump was, the more likely it was to burn out in a single event, whereas the green stumps only partially burned (Timmons and others 1996). In another study, observations at a prescribed burn in northwestern Montana revealed many of the Douglas-fir stumps left from 80 years of logging were rotted and massive in size. In a 1-acre sample plot placed in a relatively open forested landscape, 43 stumps were counted. Around 688 stumps were estimated within the boundary of a 16-acre (0.06 $km^2$) buried prehistoric site. Even in the light intensity spring burn conducted on the site, approximately 20 stumps within the 1-acre plot burned out. The results were stump cavities as large as 1-½ meters in diameter and depth, with root cavities extending out 5 meters (16.4 ft). If there were hearth or stone-boiling features that intermingled with the roots, the feature would collapse and artifacts dropped in the profile (fig. S-3b,c). Holes created by the burned out stumps comprised approximately 0.4% of the burn area.

In a field experiment, simulated "fire-cracked rock features" were placed next to stumps in a prescribed burn area. The lithic features located adjacent to burned out stumps were disarticulated and redeposited (Timmons and others 1996). It is also quite possible that an artifact could be thermally altered if located directly against the stump. However, as little as 0.8 centimeters (2 in.) of soil between the artifact and the stump would likely insulate it from the heat given off from the burning stump. While we cannot rule out the possibility of artifacts or even features being adversely affected by a burning stump, we have greater control of the percentage of stumps that are burned in a prescribed fire than we would if wildland fire burned through the accumulation of heavy fuel loads. Not only would wildland fire impact a greater percentage of the site, but would also increase the severity of impacts to the artifacts (fig. S-3b,c).

A slow, creeping fire, smoldering in thick duff also has potential to adversely affect cultural properties, as does heavy accumulations of standing vegetation. Total removal of duff may also expose surface features and artifacts to erosion and vandalism, due to increased visibility. Careful planning and monitoring of prescribed burns will reduce the potential for adverse effects and identify the need for subsequent rehabilitation measure, like those used following wildfires. Mitigation measures, such as mulching or concealment may be required to reduce the potential for erosion and vandalism, respectively.

## Sidebar 9-3—Stump Burn-Out: Feature Damage

Stratigraphy, the laying down of layers over time, is an important factor in archaeological interpretation; undisturbed artifact or feature depth is related to time since the cultural resource was last used or deposited. Trees often grow in close association with cultural resources. Midden soils and wind-blown loess soils create favorable habitats for establishment and growth of woody plants, which eventually die. Wind-throw trees can result in ripping the root ball out of the ground creating a mound and depression microsite and redistributing cultural materials. The stump, whether occurring naturally or because of historical logging, eventually decays (fig. 9S-3a) leading to a fuel capable of sustained flaming and smoldering. The subterranean character of stump holes and root channels (fig. 9S-3b) creates the opportunity for sustained extreme heating potentially damaging surface and subsurface artifacts and features. This can be a confounding site formation effect for archaeologists (chapter 7; Conner and Cannon 1991; Conner and others 1989; Timmons and others 1996). The residual hole left after burning can collapse, redistributing cultural materials (fig. 9S-3c). Mop-up during fire suppression poses additional hazard to artifacts through rapid quenching or mechanical disturbance.

A

**Figure 9S-3a—**Rotten stump 40 years after partial cutting of the forest.

B

**Figure 9S-3b—**Burned-out stump hole revealing collapsed rocks.

C

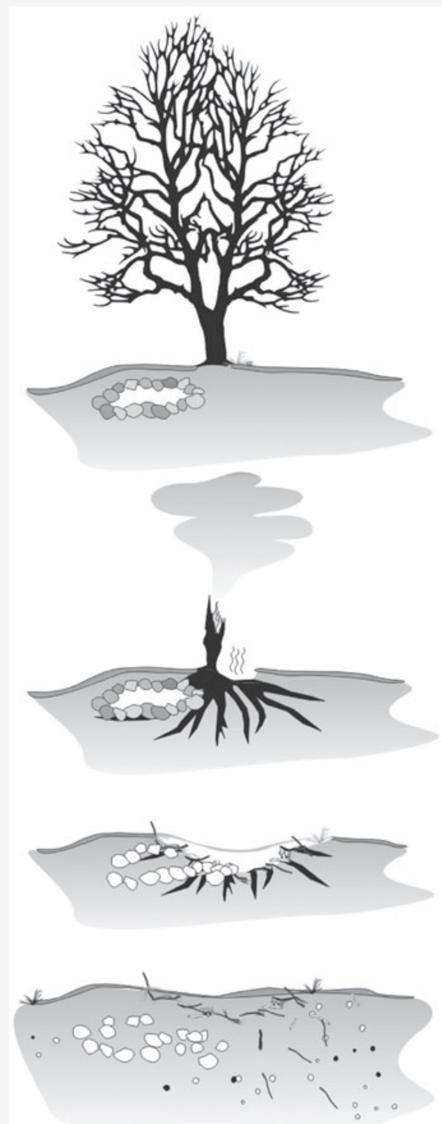

**Figure 9S-3c—**Stump burn-out and cultural resource damage. Trees commonly grow in or adjacent to features as in this illustration of an archaic hearth. Root expansion during the tree's life can displace artifacts. Subsequent burn-out of the stump and roots can cause collapse and redistribution of artifacts as well as affect dating techniques.

## Prescribed Fire Management Recommendations

The risk of negative impacts from prescribed fire to eligible or potentially eligible cultural sites can be minimized through proper planning. The planning, implementation, and monitoring of prescribed burns are best accomplished through applying a team approach of cultural resource specialists and fire managers.

Cultural Resource Specialists:

- Conduct project inventory to identify cultural properties and obtain the necessary clearances (legal compliance) for the proposed burn area in order to assess project effects to cultural properties. The inventory should include ethnographic (tribal) information about cultural properties (as associated with cultural sites) and treaty rights-related resources (as associated with plants, etc.). Consider all cultural sites with surface artifacts or features as sites at risk and design specific protection measures accordingly.
- Provide cultural information (location, provenience, site description, areas of high potential for resources).
- Consult with American Indian Tribes and First Nations regarding the project intent and dates.

Fire Managers:

- Determine the type and loading of fuels in order to obtain estimates of potential fuel consumption and surface and subsurface temperatures and work with cultural specialists to determine how these combinations could affect cultural materials.
- Identify the fuel models and vegetation types to help determine the potential heat that may be generated under different fuel moisture, weather variables, and ignition patterns.
- Formulate a burning prescription and work with cultural specialists to ensure that all significant cultural properties are protected. Carefully consider burning strategies that might reduce potential effects. For example, a head fire might cause fewer effects to artifacts on the ground surface than a cooler, slower moving backfire with a longer residence time (chapter 2).
- List all burn preparation needs in the burning plan and ensure that they are implemented before burning.
- Brief all fire support personnel on the objectives of the burn and engage the cultural specialists to discuss the proper protection of cultural properties and materials.

Removal of heavy fuels is the most useful preventive measure for lessening the impacts of fire on surface cultural materials. This includes deadfall, snags, and heavy brush, all of which have the potential to burn hot. Light fuels such as grasses and thin duff will usually produce low heat and residence time resulting in minimal impact on the surface. Under common prescribed burning conditions grass fires typically result in smoke-blackened artifacts and features, which retain their interpretive potential after they are affected. While heavy fuels are the greatest threat to surface cultural materials, stumps and roots present the greatest potential source of heat penetration into undisturbed sub-surface cultural deposits. A trained cultural resource specialist should determine the best treatment measures, which might include:

- Avoid burning heavy fuel accumulations; if present, remove the concentrated fuels from the sensitive sites. Trees, snags, and large shrubs should be removed from cultural resource sites when they are identified as having the potential to adversely impact the resource. Particular care should be directed to the location and burning of any slash piles.
- Hand removal of any fuel source may be necessary. Some resource types such as pictographs, petroglyphs, bedrock mortars, and milling features may be damaged by the presence of even light fuels.
- Treat stumps by wrapping them with fire resistant-reflective fabric; application of water, retardant, or foam; or bury stumps with soil, rocks, or similar material to prevent ignition during a fire. Accelerating stump decomposition with substances designed to accelerate decomposition, or mechanical treatment of stumps by drilling or scoring may be helpful. However, physical removal of a stump by mechanical means could have as much or more impact than the fire itself.
- Remove standing, dead trees from sensitive cultural resource sites to prevent tree tip-up.
- Isolate vulnerable cultural properties from the fire by creating foam barriers, building carefully prepared hand lines, and establishing hose-lays.
- Remove deadfall from sites, particularly from surface features. When planning for prescribed fire, it is in the best interest of the resource to minimize the ignition of trees, deadfall, and stumps.
- All trees, shrubs and brush growing in and near cultural features should be assessed and removed as appropriate. Planning for removal of live vegetation should include consideration of whether erosion would be accelerated when trees and large shrubs are removed or whether exposure of the feature to looting outweighs any potential benefits. It would not be appropriate to worsen erosion or looting hazards while attempting to control potential fire impacts.

## Fire Rehabilitation

Fire rehabilitation activities following the fire should receive the same level of attention as that used in designing the implementation of a prescribed burn (sidebar 4). A cultural resource specialist should be involved in the development of rehabilitation plans to identify site-specific mitigation measures for cultural properties. Mapping the location of post-fire treatment areas and specific rehabilitation activities for cultural sites will help assure avoidance of any further damage to resources. Individual cultural resource site records should be updated to reflect any changes that occurred as a result of the rehabilitation activities.

### Fire Rehabilitation Recommendations

Caution should be exercised when implementing post-fire treatments (Robichaud 2009; Robichaud and others 2000) to avoid damage to cultural resource sites. Physical treatments common as rehabilitation measures include aerial or ground application of mulches, straw wattles, reseeding (preferably with native species), mechanical revegetation, construction of contour trenches, and water barring. Recommendations for mitigating potential adverse effects during rehabilitation should be specific to cultural sites, outlined in formal *Determinations of Effects*, and reviewed by the State historic preservation office or the tribal historic preservation office. Recommendations should be implemented as soon as possible to prevent resource loss due to erosion and looting. Some recommendations to consider are:

- Backfilling stump cavities to prevent collapsing of sediments around features. The locations should be carefully documented for reference by future cultural resource specialists.
- Reseeding of devegetated areas with vegetation that does not contribute to vertical displacement of buried cultural materials.
- Installing log diverters to redirect the flow of water away from vulnerable areas of a site.
- Removing standing, dead trees inside of features to prevent tree tip-ups caused by falling and possible later ignition by fire.
- Consulting with a rock art conservation specialist to assist in identifying appropriate treatment.

In the United States, recommendation options may be compiled and agreed to by the agency, the State Historic Preservation Office, the Advisory Council on Historic Preservation, and interested tribes in a Programmatic Memorandum of Understanding (PMOA). A PMOA can be negotiated on a local forest or regional level as tiered to any national PMOA. At present there is a multi-agency effort to produce a national PMOA on Wildland Fire Management and Cultural Resources.

## Fire Use

In the United States, some naturally ignited fires are allowed to burn under specified, prescriptive conditions in order to meet resource objectives. As such these fires pose some challenges that are somewhat unique. Such fires are typically in more remote areas and often within legally designated wilderness areas where mechanized fire suppression is limited. In contrast to wildfires that are suppressed as quickly as practical, such resource benefit fires may be allowed to burn for weeks or months. In such situations planning for cultural resource protection is more similar to that of a prescribed fire in that there is a greater opportunity for planning and coordination. The remoteness of the resource changes the risk factors, such as those posed by heavy equipment, but also changes the monitoring and rehabilitation opportunities requiring both fire managers and the cultural resource specialists to adapt their practices (sidebar 9-5).

### Fire Use Recommendations

The use of cultural resource data to support wildfire planning has traditionally been a management issue. The disclosure of cultural resource data has typically been such that the release or exchange of information with wildfire staff is cumbersome and at times non-existent. Protection of cultural site location information is mandated by the Archaeological Resource Protection Act. It is exempt from public disclosure, but can be made available to other agency personnel on a need-to-know basis, which includes information needed to protect a cultural site. The lack of information including site location, site probability, and fire susceptibility can impact planning for wildfire decisions and prescribed fire projects.

CR data, along with other datasets, are needed on an interagency basis to support national applications, planning, and wildfire suppression efforts. To facilitate the collection and standardization of these datasets, the Federal agencies are developing a wildfire geodatabase (Wildland Fire Distributed Information System) that would pull cultural resource data from various sources and make it available for wildfire response teams. This is not intended to store or create a national dataset of site specific locations but provide generalized locations that include material types (for information on susceptibility to fire) and site depths.

In the United States, an application that will use these data is the Wildland Fire Decision Support System (WFDSS) (Noonan-Wright and others, in press). WFDSS runs Finney's fire spread probability model (FSPro) (Finney and others 2011) that calculates the probability that a given area will burn based on thousands of simulations of historic fire weather. This probability layer is then intersected with multiple data

## Sidebar 9-4—Protecting Cultural Sites From Erosion

Burned Area Emergency Rehabilitation (BAER) is frequently used to protect cultural sites from further damage from erosion. Fire management agencies have guidelines for BAER practices, which often need modification in cultural resource areas. BAER teams working in CR areas should have CR specialist on the team to direct rehabilitation efforts and site documentation for future monitoring.

A

**Figure 9-S4.a—**Burned Area Emergency Rehabilitation work to protect a rock shelter following the 2002 Mustang Fire, Ashley National Forest, Utah. Straw wattle (foreground) was used as a runoff barrier to protect the rock shelter from water coming in from the side, which could result in erosion damage. An erosion blanket (brown patch in mid-ground) was used to protect the floor of the rock shelter from water flowing off of the overhanging ledge (Johnson 2004a,b) (photo August 2002, by Clayton Johnson, USFS Ashley National Forest).

B

**Figure 9-S4.b**—A prehistoric rock shelter shown in figure S4.a with treatments to reduce further erosion. Protection for archaeological sites must be designed to keep erosive and debris flows away from the site, and to reduce erosion on the site without further disturbing the features. Log erosion barriers are not recommended on a cultural site as they raise the risks additional damage due to mechanical disturbance and future fire damage. Note deposited sediments against straw wattle erosion barrier (lower right corner of photo) 10 months after BAER placement (Johnson 2004a,b) (photo May 2003, by Clayton Johnson, USFS Ashley National Forest).

C

**Figure 9-S4.c**—Hand mulching with straw was effectively used to protect an archaic pueblo site burned over in the 2002 Rodeo-Chediski Fire, Apache-Sitgreaves National Forest, Arizona (photo courtesy of Barbara Mills, University of Arizona).

D

**Figure 9-S4.d**—The mulching was successful, as observed in 2004 at the pueblo site, shown in figure S4.c, 2 years after the Rodeo-Chediski Fire (photo courtesy of Barbara Mills, University of Arizona).

## Sidebar 9-5—Structure Protection

Many cultural sites consist of stone, adobe, or wooden structures (log cabins, old barns, mining buildings, historic lookouts, etc.). There are three main mechanisms whereby such structures may be damaged in wildland fires: ignition from a wind-blown ember (fig. 9S-5a,b), flame contact from the burning of surface fuels too close to the structure (fig. 9S-5c), and radiant heat from an intense surface or crown fire (fig. 9S-5d,e). Spotting distance increases with the intensity of the fire and wind (chapter 2). Spotting up to a kilometer is common and spotting up 2 kilometers occurs under ideal conditions. Sprinkler systems, fire retardants, and wrapping (fig. 9S-5f) are routinely used, often in combination, to protect historic structures (fig. 9S-5g).

A

**Figure 9S-5a—**Historic cabin burned from ember-caused ignition.

B

**Figure 9S-5b—**On the evening of July 29th, 2002, historic residences burn during the Long Mesa Fire, Mesa Verde National Park, Colorado. On the evening of July 29th, embers from the blaze landed on rooftops and entered into attic spaces. Three residences were lost along with other infrastructure.

C

**Figure 9S-5c—**Damage to a sandstone wall caused by direct flame contact during the 2002 Long Mesa Fire, Mesa Verde National Park, Colorado.

D

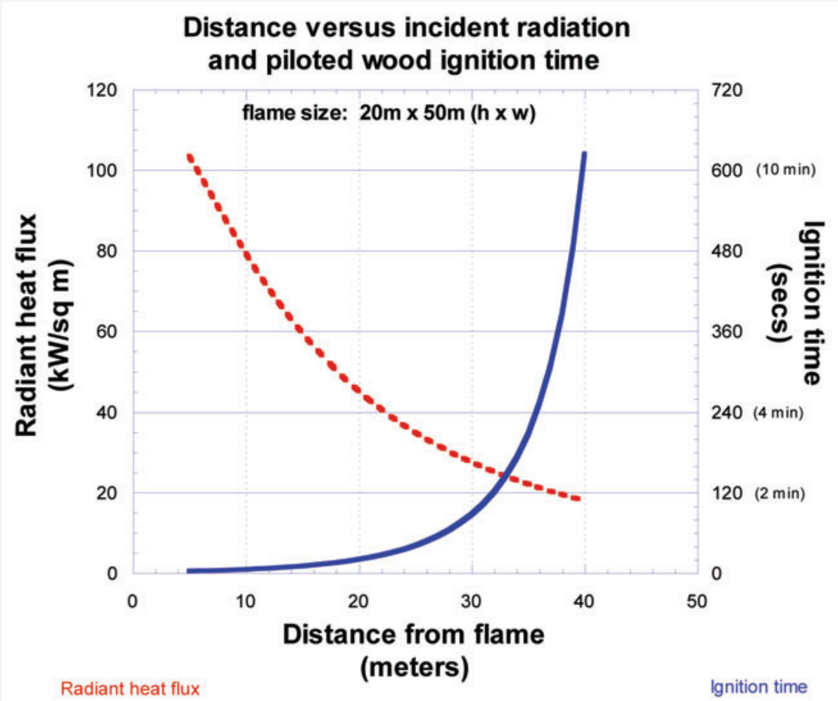


**Figure 9S-5d—**The radiant flux from an intense crown fire decreases exponentially with distance. Correspondingly, the exposure time to ignition increases exponentially with distance from the flame-wall. Because fine canopy fuels burn out quickly (<2 minutes), peak intensities can not be sustained long enough to ignite wooden structures at a distance greater than about 30 meters (~ 100 ft.) (Cohen 2000).

E

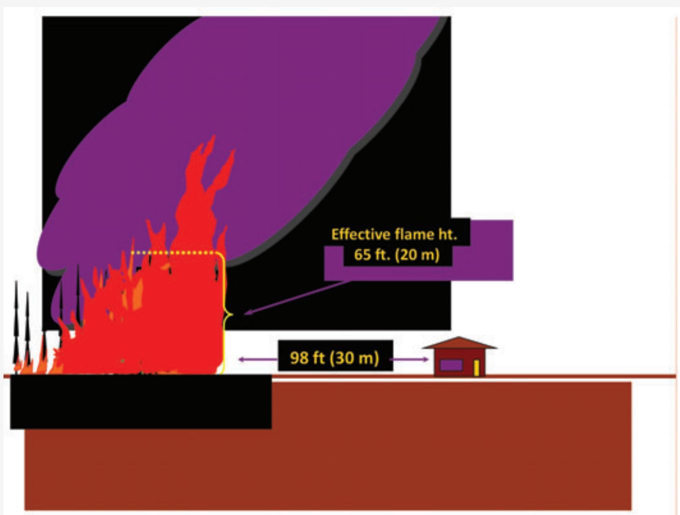


**Figure 9S-5e—**Modeling can be used to predict the distance from a structure that fuels need to be treated to protect structures from direct flame ignition.

F

**Figure 9S-5f—**Crews commonly wrap back country structures with fire shelter cloth to minimize structure ignition.

**Figure 9S-5g—**Little Snowy Lookout following foil-wrapping and pretreatment with aerial retardants.

layers such as structures, roads, ownership, and other significant values at risk in the Rapid Assessment of Values at Risk model (RAVAR) (Calkin and others 2008, 2011; Thompson and Calkin 2011). A report is generated detailing the probability that these resources will be impacted by the spreading fire. The fire's risk to a cultural resource feature class can be a component of this report. To support the WFDSS analysis, the cultural resource layer will consist of several attributes that provide basic information about sites so that fire staff will have a basic understanding about the condition of the site, the fire sensitivity of the site, and possible management mitigations or avoidances to better protect the site.

Another tool for fire planning is a decision-making matrix, developed for the National Park Service that is being used as a planning tool to convey essential information regarding cultural resources, their contexts, values, and the activities needed to identify and manage them within fire situations. Inventory strategies, management objectives, and treatment options can be designed to plan for fire events by defining cultural resources and their components. This allows specialists to see, at a glance, a summary of what resources are present and how they may be effectively managed and protected. By looking at the historical context of a landscape, surveyors are able to examine historic techniques that may influence management tactics for the future. By using generalized language to describe resource types, security can be maintained to protect actual site content while still giving enough information to allow for effective management decisions within and around the resource sites.

In addition to categorizing resources, the matrix places resources in multiple contexts; defining what elements are at risk, what needs protection, and the integral characteristics to be preserved. Creating a risk matrix also compels administrators to identify possible risks directly or indirectly caused during and after management, ranging from artifact displacement to complete obliteration in some cases. The matrix also calls for inventories of sites and suggestions of future inventory methodology, associating temporal data with each resource. After compiling what resources are within the specified area, land management decision makers and cultural resource specialists collaborate to create appropriate management objectives to achieve a desired condition. When the objectives are established, several treatment options are proposed to obtain the desired conditions, and managers use the best research available to choose the best treatment alternative to implement. Table 9-2 is a specific example of the matrix provided by Great Smokey National Park where cultural resources from both the prehistoric and historic periods and major resources which must be preserved in fire and vegetation management activities.

## Summary

A large amount of data is becoming available concerning various dimensions of cultural resource management. These data include detailed information on the different cultural resource materials and how they are changed by fire. The behavior of fire and associated combustion processes are well understood, as are impacts of fire on vegetation, soil, and water. The direct and indirect effects of activities associated with wildland fire have been well defined. There is immediate need to bring together the wide array of information into a format that managers can use while fighting wildland fire or for planning burns. The information should be synthesized into a workable set of guidelines for protection of cultural resources. Integration of cultural guidelines with Fire Management Plans, MIST Standards, emergency discovery plans, and fire management handbooks is critical.

**Table 9-2**—Matrix for evaluating potential impacts of fire management activities on cultural resources. Example from the Great Smokey National Park. Matrix developed by Robert J. Jackson, Pacific Legacy.

| Historic context[a] | Resource type[b] | Properties at risk[c] | Elements[d] | Risk conditions[e] | Inventory method proposed[f] | Management objective desired condition | Treatments alternatives/options |
|---|---|---|---|---|---|---|---|
| **Archaic Prehistoric** | Res. procurement camp | Lithic scatters/flaked stone | Chert | Displacement from ground disturbance | Documents search, predictive modeling, shovel tests in low slope areas and gaps | Map, maintain site stability and data potential of site components | Remove heavy fuels |
| | Base camp | Ground stone | Quartz | Breakage from heavy equip./ heating | Documents search, predictive modeling, shovel tests in low slope areas and gaps | Maintain cool surface temp | Reduce duff consumption |
| | | Fire cracked rock | Granite | Confounding of thermal dating | | Avoid crushing artifacts | Line w/o mineral soil disturbance |
| | | Charcoal | Sandstone | Mistaken raw material type/discoloration | | Maintain context | No heavy equipment |
| | | Steatite vessels | Steatite | Contamination from new charcoal | | Map locations | Reduce subsurface burning |
| | | | Charcoal | Displacement from erosion | | Avoid charcoal contamination | Post burn stabilization |
| | | | | | | | |
| **Euro American farming** | Homesteads | Houses, furniture and household goods, outbuildings, apple houses/storage, yards, springhouses, ornamental/food plants, trash | Wood, stone, metal, rubber, plastic, glass, brick, cloth, cement, ceramic, leather, living exotic plants | Breakage from heavy equipment/ heating | 20 of the 30 known homesteads have been recorded. The last 10 should be revisited and recorded. | Case by case assessment due to high number of sites and different mgt. objectives by park district | Remove adjacent fuels, maintain greenways, burn during high soil moisture season, engine nearby and monitor during burn, sprinklers, wrap in fs cloth |
| | Fields/Pastures | Fences, rock walls, cultivated species, trash | Wood, stone, metal, rubber, living exotic plants | Artifact displacement from erosion | | Case by case assessment due to high number of sites and different mgt. objectives by park district | Mow and wet line fences, monitor during burn and extinguish. |
| | Roads | Earthwork features, rock walls, vehicles, bridges, trash | Wood, stone, metal, rubber, plastic, glass, cement, ceramic, leather, living exotic plants | Loss of features/ Ground disturbance and erosion | Historic maps checked to determine roads that have not been recorded. | Case by case assessment due to high number of sites and different mgt. objectives by park district | Fuel removal or monitor on case by case basis |
| | Orchards | Fruit and nut trees, wooden fences, rock walls | Wood, stone, metal, glass, living exotic plants | Loss by burning of cultivated plant spp. | | Case by case assessment due to high number of sites and different mgt. objectives by park district | Rake around trees, monitor during burn |

[a]Historic contexts are the themes, activities, events or time periods that are represented by cultural properties.

[b]Resource types are categories of physical objects or properties that share common attributes, elements, and usually functions.

[c]Properties at risk are those that have cultural value and are likely to be damaged by fire activities.

[d]Elements are the basic building blocks or constituents that make up a resource.

[e]Risk conditions or activities are the project actions that could damage elements of resource types.

[f]Inventory method is the manner in which these properties should be located and recorded or revisited.